SCIENCE

Vol. 91 FRIDAY, JUNE 14, 1940 No. 2372

SCIENCE: A Weekly Journal devoted to the Advancement of Science, edited by J. MCKEEN CATTELL and published every Friday by

THE SCIENCE PRESS

Lancaster, Pa. Garrison, N. Y.
New York City: Grand Central Terminal

Annual Subscription, $6.00 Single Copies, 15 Cts.

SCIENCE is the official organ of the American Association for the Advancement of Science. Information regarding membership in the Association may be secured from the office of the permanent secretary in the Smithsonian Institution Building, Washington, D. C.

MINUTE AMOUNTS OF CHEMICAL ELEMENTS IN RELATION TO PLANT GROWTH[1]

By Professor D. R. HOAGLAND

UNIVERSITY OF CALIFORNIA, BERKELEY

A GENERAL survey of the history of plant and animal nutrition during the past two decades records notable advances in scientific knowledge, many of which have been made possible only because of the recognition and experimental control of organic and inorganic substances in micro-quantities. The investigator of the nutrition of higher plants, which can grow in solutions of purely mineral character, has certain advantages of technique not enjoyed by the investigator of animal nutrition, in the study of the relation to the growth of the organism of very minute amounts of chemical elements. Yet the plant physiologist has not always profited by these advantages. For a long period the standard teaching was that only ten chemical elements (nitrogen, phosphorus, sulphur, calcium, magnesium, potassium, iron, carbon, hydrogen and oxygen) were generally indispensable for the growth of higher plants. Many other elements, if found to be effective at all, were regarded merely as plant stimulants or poisons. Following earlier work in France, Mazé[2] presented in 1914 certain evidence, based on controlled water-culture experiments, of the requirement for normal growth of the maize plant of chemical elements not included in the list of ten, but his experiments

[1] Presented before the National Academy of Sciences, April, 1940, as a highly condensed review, for the information of those who have not had occasion to refer to the literature of this field.

[2] P. Mazé, *Ann. Inst. Pasteur.*, 28: 21–68, 1914.

received but scant attention until much later. Then Warington,[3] at the Rothamsted Experimental Station in England, on the suggestion of a research conducted for another purpose, discovered an essential role for boron in the growth of the broad bean and several other plants. Appreciation of the wider significance of this observation, however, did not immediately follow. About the same time McHargue[4] and others became convinced, as a result of extensive experiments, that manganese was an indispensable component of a nutrient solution. During this period Sommer and Lipman,[5] and Lipman and Mackinney,[6] and Sommer,[7] conducted painstaking experiments with the use of highly refined technique which led definitely to the conclusion that the varied species of plants studied could not complete their cycle, or indeed might show complete growth failure, without minute but determinable quantities of boron, copper and zinc, as well as manganese. Within the past several years two of my colleagues, Dr. Arnon and Dr. Stout,[8] have provided evidence that gives very strong support for the view that molybdenum is likewise one of the indispensable elements for higher plants. It had been shown to be essential for certain fungi by Steinberg.[9] This, of course, does not necessarily complete the list of essential elements. There are indications that still others may be added, but the evidence is not yet conclusive for complete indispensability for a wide range of plant species.

The effective amounts of the elements in question are not quite so spectacularly small as those involved in plant responses to certain hormones and vitamins. Nevertheless, extremely low concentrations produce visible effects, for example, one or two thousandths of a milligram of zinc in a liter of nutrient solution, though much more may be required for continued normal growth. Boron and manganese are now generally accepted as essential elements, but some plant physiologists still seem reluctant to include copper and zinc, although the evidence is equally positive, if not so extensive. In our experience with many species of crop plants, we have not failed in any case to find copper and zinc requirements.

Not infrequently the chemical elements required in minute quantity have been designated as "minor" or "accessory" elements. This may be misleading—such elements are essential for growth just as are nitrogen, phosphorus and potassium. The term "micro-nutrient elements" is possibly suitable as a general designation. The commonly used term "trace" elements seems to me to fail to convey the idea of quantitative relations. Technique for growing plants under controlled conditions has now advanced sufficiently to permit quantitative studies to be made of successive minute increments of the elements boron, copper, manganese, zinc and molybdenum.

To prove decisively the indispensability of elements of the category under discussion, for varied species of plants with different quantitative requirements, the utmost care must be taken in the refinement of methods of culture. At one time the question therefore arose as to whether in general experiments in plant nutrition, and especially in agricultural practice under natural soil conditions, one need be concerned with elements like boron, copper, manganese and zinc. This question can now be answered with complete confidence. In the experiments of the plant physiologist, conducted without special attention to these elements, their presence in adequate amounts depends on accidental factors of choice of chemicals, distilled water or culture vessels, which yield uncontrolled contributions of micronutrients. Earlier investigations on the effects of different nutrient solutions on plant growth will need re-examination in the light of this consideration.

More surprising is the evidence incorporated in hundreds of reports received during the past few years from many parts of the world, that under certain field conditions crop plants may fail to make normal growth, or may become diseased, through deficiency of boron, copper, manganese or zinc, as the case may be. It is too early to draw any general conclusion about molybdenum. Especially numerous are instances of boron deficiency, to which commercially important diseases of the sugar beet, celery, apple, alfalfa and many other crop plants are attributed. Frequently such boron deficiencies have been corrected economically by application to the soil of boron-containing compounds. There is, however, another aspect to the boron question which has been made clear by investigations in California during recent years. Those elements essential for plants in minute amounts may also become toxic at concentrations in the nutrient medium which are still very small. The physiological range is sometimes relatively narrow. Thus, some irrigation waters may add to the soil so much boron that severe injury to sensitive crops is produced. This has become an important economic question in some western areas.

Turning to another illustration of deficiency causing plant disease, an explanation is now available of the previously entirely obscure nutritional disorders of fruit trees known by such names as "little-leaf," "mottle-leaf" and "rosette." These trees are, in fact, suffering from a deficiency of zinc, minute as the requirement is. It was at first very difficult to believe that a simple zinc deficiency was involved. Consider,

3 K. Warington, *Ann. Bot.*, 27: 629–672, 1923.

4 J. S. McHargue, *Jour. Agr. Res.*, 24: 781–794, 1923.

5 A. L. Sommer and C. B. Lipman, *Plant Physiol.*, 1: 231–249, 1926.

6 C. B. Lipman and G. Mackinney, *op. cit.*, 6: 593–599, 1931.

7 A. L. Sommer, *op. cit.*, 6: 339–345, 1931.

8 D. I. Arnon and P. R. Stout, *op. cit.*, 14: 599–602, 1939.

9 R. A. Steinberg, *Jour. Agr. Res.*, 52: 439–448, 1936.

for example, a specific case of a peach orchard which had become diseased while growing in soil containing within the root zone a total of approximately 3,000 pounds of zinc per acre and that at seven years of age the trees had removed only about one half pound of zinc from the soil. Nevertheless, controlled experiments by water-culture technique, and other evidence, brought conviction that zinc deficiency was indeed the cause of the disease. Obviously, many very difficult questions need answer with regard to the availability of zinc in the soil to the plant. Some experiments made in California suggest that, at least in certain soils, this availability may have a relation to the growth of soil microorganisms which may themselves absorb zinc. There is another type of disease that may affect fruit trees in the field, caused by deficiency of copper. Here also similar symptoms have been reproduced in plants growing in culture solutions lacking only in copper. Manganese deficiencies for various kinds of plants under field conditions are well known and can be reproduced under controlled conditions.

These are only illustrations of the significance to agriculture of chemical elements effective in minute amounts. As I have indicated, the volume of evidence is now impressive. But lest a misunderstanding be created, I should like to emphasize that not all soils are deficient in ability to supply these elements to the plant and, furthermore, when a deficiency exists, it does not necessarily follow that it will be corrected by the use of some fertilizer containing minute amounts of the element in question as an impurity. The so-called fixing power of the soil enters as a most important factor, but I have no time to discuss this point. In practice deficiencies sometimes have to be corrected by direct application to the plant of the deficient element, by spraying or other means.

In the field of study of which I am speaking practical application has followed rapidly on research already performed. But this research is still inadequate in that our knowledge of the functions in plant metabolism of the mineral micro-nutrients is extremely limited. A deficiency of boron has profound effects in all the meristematic regions of the plant. Yet, so far as I am aware, we have no really satisfactory hypothesis concerning chemical reactions in the plant in which boron might assume an indispensable role. And this role is specific to boron, as very extensive experiments with other chemical elements demonstrate. This is a problem of general interest to the cell biologist. The possibility does not seem to have been definitely excluded that minute amounts of boron may have a function in animal cells.

The basis of knowledge is more satisfactory for the development of an understanding of the functions of the metals utilized in minute amounts. Outstandingly important advances have been made in general research on oxidation-reduction systems in living organisms. The oxidation of carbohydrates involves intricate enzyme systems, in which hydrogen carriers, or electron transmitters, have a place. The role of iron, dependent on changes in valence states, has of course been considered for a long time. On the general question of metal catalysis Szent-Györgyi[10] draws the following conclusion: "Such oxidations are catalyzed by metals outside the cells; and when the cell used metals to catalyze oxidation, it did not invent a new principle; it merely applied an age-old reaction, but applied it in a very clever way: linking metal to a specific protein in the cell and thus giving it a chance to act at its best." Recently copper has been reported as an essential constituent of certain oxidase systems, which are of importance in plants. Some recent work indicates that manganese is essential to respiration and nitrate reduction in the plant. Another investigation suggests that a zinc protein enzyme catalyzes the reaction of carbonic acid to water and CO_2. The work was done on blood cells, but a similar enzyme might function in the photosynthetic system, although this has not been proved. In preliminary studies in our laboratory by Skoog a secondary effect of zinc deficiency was observed on the auxin growth substance content of the plant, the zinc deficient plants yielding much less auxin activity than those with an adequate supply of zinc. This seems to be consistent with effects of zinc deficiency in retarding elongation. In general, there appears to be justification for the assumption that minute amounts of inorganic elements and minute amounts of organic substances may frequently be associated in their actions. On the basis of present knowledge, it should be feasible to study some of the possible relations of micro-nutrient elements to the synthesis of vitamins or their precursors by the plant.

Essential metal deficiencies commonly produce chloroses of varied types in green plants, but aside from marked failures of chlorophyll synthesis, suggestions have been made of effects on photosynthetic efficiency. The investigators of photosynthesis are in the midst of a reexamination and reinterpretation of estimates of quantum efficiency in photosynthesis, so that it is not very safe to refer to this question. I might note, however, that Emerson and Lewis[11] in studies on Chlorella utilized certain combinations of mineral micro-nutrients employed in experiments in this laboratory with crop plants, and found large increases in the quantum efficiency, by the particular technique of experimentation adopted. Whatever the final interpretation of these experiments may be, the general question involved is of importance to plant

[10] A. Szent-Györgyi, *Bull. N. Y. Acad. Med.*, 15: 456–468, 1939.

[11] Emerson and Lewis, *Amer. Jour. Bot.*, 26: 808–822, 1939.

nutrition. What are the concentrations and relations of metals in the green cell conducive to the largest synthesis of sugar permitted by other factors in the environment? Evidence on this point is being developed.

Increasingly, the workers in animal and plant nutrition are finding common interests in their researches on minute factors in cell metabolism. We are beginning to appreciate that the plant does not synthesize vitamins or their precursors merely as a philanthropic act for the benefit of the animal. These substances first of all may have a function in the plant itself. Likewise, many inorganic elements, including at least several of the micro-nutrient elements, are indispensable to plant and animal alike. But the qualitative or quantitative requirements are not always coincident. Investigators are now asking how the environmental factors influencing the composition of the plant are related to its value as a food for animals; in other words, how do climate and soil and fertilizer practice affect nutritional quality? The old problem of iodine deficiency in the animal is too familiar to warrant discussion, save to remark that in recent experiments in Berkeley with several types of plants it has not been possible to show so far that iodine is an essential element for the growth of crop plants, within the limits of technique now available. An interesting example of a differential requirement for plant and animal is that of the cobalt-deficiency disease of sheep and cattle extensively studied in New Zealand and Australia. The cobalt deficiency in certain soils did not prevent pasture plants from growing, but the animals suffered for lack of cobalt in the ration. Apparently deficiency of copper for the needs of animal nutrition may also occur in various regions. Manganese deficiencies require further study.

On the other hand, there exists the possibility that the plant might absorb special mineral constituents of the soil in such amounts as to produce a toxic food stuff. One instance of this kind has been carefully investigated by the United States Department of Agriculture, the South Dakota Agricultural Experiment Station and other research agencies. Some species of plants growing on selenium-containing soils absorb so much of this element that the plant becomes severely toxic to the animal. It is an interesting aspect of plant physiology that ability to accumulate selenium from the same soil medium varies strikingly among different species of plants. We also note that plants may absorb fluorine, arsenic, and other toxic elements, if they are naturally present in, or added to the soil.

The whole subject of soil and plant interrelations in its bearing on problems of animal nutrition has been deemed of sufficient importance to warrant its inclusion as a major research objective by one of the Department of Agriculture's new laboratories. The field is ready to be explored, but only long and patient cooperative research on the part of plant and animal physiologists, soil chemists, and probably plant breeders, can determine the extent of existing quality deficiencies in crops and the feasibility of modifying the quality by commercially practicable procedures. Broad generalizations on this aspect of micro-nutrients are not admissable on the basis of present information.

SCIENCE IN GENERAL EDUCATION AT THE COLLEGE LEVEL[1]

By Dr. LLOYD W. TAYLOR
PROFESSOR OF PHYSICS, OBERLIN COLLEGE

A few years ago the writer was examining the portraits of Sir Isaac Newton in the British Museum. The museum keeps a file of negatives of portraits that are in the greatest demand. In response to an inquiry whether that file included any of Newton, the attendant replied: "Oh, no, sir. We 'as 'em of the fymous men, sir, but not 'im, sir!"

Instances are not lacking of a similar obtuseness on this side of the Atlantic as to the importance of the sciences. It is true that until fairly recent years sciences in American education were riding a strong wave of popular approval which originated in the last quarter of the nineteenth century. But lately there has been a reaction and the trend is now in the opposite direction. This is being reflected in shrinking registrations in all the high-school sciences on a scale which is positively catastrophic. In colleges the corresponding ebb is being stemmed by the science requirement. But pressure is accumulating toward the elimination of that requirement and the contraction of the sciences in the program of higher liberal education will ultimately be the more pronounced in consequence of its deferment.

Two years ago the American Association for the Advancement of Science set up a special committee to try to identify the problems involved in adapting the sciences to the requirements of general education at the college level. Though this paper is in considerable measure an outgrowth of that study, it is in no sense a report of the committee. Some of its subtopics did

[1] Invited paper, given before the American Science Teachers' Association at its meeting at Columbus, Ohio, on December 28, 1939.

not come before the committee at all and others doubtless express sentiments upon which the committee would not be willing to go on record, or from which it might even dissent. The committee is accordingly hereby absolved from responsibility for any deductions drawn, though free use will be made of some of its statistical studies.

"Pearls before swine" is the defense reaction sometimes elicited from teachers who hear of diminution in student favor toward their subjects. But let us hear some reactions that are presumably more carefully considered. Of more than 1,000 college teachers of science[2] who expressed an opinion, more than two thirds felt that their offerings were justifiably less than completely acceptable to students whose interest in the subject was not primarily professional. They felt that general courses in science were being aimed primarily at the minority who were later to specialize, and were disregarding the best interests of the non-specialist majority.

Many things could be said on the bearing of this state of affairs on the downward trend of the sciences in the educational scheme and on what should be done about it, not so much to save the sciences as to save the educational scheme, but this is not the occasion. Some are not convinced that there is any danger of the sciences being eliminated from the general educational program. They possess a facile optimism that the sciences will remain in the education system because society can not exist without science. This is a *non sequitur*. Rightly or wrongly, disillusionment with the laboratory is in the air. Let the facile optimist read only a little history or look around him at contemporary events to see the excesses to which popular disillusionment will carry a mass movement.

In the course of its investigation the committee received replies from college and university teachers of science to another question: "What do you believe are the most significant contributions which a study of (your science) should make to those students who are not to specialize in it?" More than 80 per cent. felt that one of the most important contributions was to develop the ability to think critically. All the rest, except 3 per cent., believed this to be of some importance, though they did not accord it so high a place. This is an interesting response in several respects. For one thing, development of the ability to think critically seems to have been considered the *most* important contribution that the sciences can make to general education, for none of the suggested alternative answers received as large a vote as this and there was no significant trend in the supplementary answers. It is perhaps natural that the physical sciences (physics, chemistry, mathematics) were somewhat more categorical on this point than the others, critical thinking being given first place by an 84 per cent. vote in the physical sciences and a 76 per cent. vote in the others. This seems to accord the palm to the non-physical sciences for the more critical thinking about critical thinking.

This remark is made with some measure of seriousness. The ability to think critically has been the central quest of the educational process ever since education came to be one of the significant cultural values. Unquestionably, the educational process as a whole aids greatly in the development of this desirable trait, but there seems to be a great deal of question about the superiority of any one subject over another in this respect. There is little evidence to indicate that men of science are able to think any more critically about such issues as the complicated political situation in the world at large to-day than are men of equal training in other fields. Let us not forget that two generations ago a virtual monopoly on training in the ability to think critically was declared by the ancient languages. In those days the attempt to develop critical thinking was called "formal discipline." When the bubble of formal discipline was pricked by modern educational psychology, the classics experienced a major loss in prestige, much to the impoverishment of the educational world. The sciences will do well to try to avoid a similar debacle, but they have already gone far toward committing themselves to a parallel educational theory.

Considerable unanimity was reached also on another point. Seventy-four per cent. of those answering the same question, namely, as to the most significant contributions which the study of their respective sciences should make to non-specialists, attributed great importance to making students familiar with the facts, principles and concepts of the science in question. All except 2 per cent. of those remaining felt that this possessed some importance, though they did not accord it as high a place as did the 74 per cent. The importance of subject-matter would seem to be a much more secure position to take than to urge the preeminence of science as training in critical thinking. One can not help connecting the favorable attitude toward the critical thinking question with the large agreement, already commented upon, that our general courses are not as well designed as they might be to meet the requirements of non-specialists. That a good training in subject-matter does promote ability to think critically *about that subject* can scarcely be gainsaid. May not the uneasiness which so many felt about the value of the subject-matter itself have led them to seize upon the critical thinking doctrine to bolster up a waning faith in their present classroom procedures?

This interpretation receives some support in the answers given to another question. Seventy-six per

[2] Statistics compiled by L. M. Heil and P. E. Schaefer, research assistants to the committee.

cent. considered very important the clarification of a point of view for teachers concerning the place of science in general education. Less than 5 per cent. considered it of no importance. It seems fairly obvious that this question would not have been answered that way unless some need were being felt for such clarification. The expression of this need is perhaps the most heartening element in all the labors of the Committee on the Improvement of Science in General Education. One might almost say that the whole, somewhat cumbersome, undertaking could be justified on the basis of that one answer alone. It disposes, at least for the sciences, of an assertion often made that education at the college level is completely in the hands of the ultra-conservatives.[3]

But while conservatives in higher education are not entirely unchallenged, they hold the balance of power. They are, for the most part, men who, primarily subject-matter specialists, as are substantially all who are engaged in college and university teaching, seem to have allowed a natural preoccupation with subject-matter to divert them from problems of how most effectively to administer instruction in such subject-matter. In some cases the preoccupation has been with research; in others, with the training of specialists in their own or allied fields, a very different undertaking than the problem of fitting one's subject into a matrix of general education. Many of these men seem not at all to sense the change in the teaching problem which has been brought about by the great mass movement toward higher education that has occurred in this country during the last fifty years.

One of the committee's observations should be taken to heart by any group of scientists. It is to the effect that the great majority of the "experiments" now under way in the teaching of science at the college level make no provision whatever for controls or any other means of checking the validity of the results. Analogous experiments in the teachers' subject-matter fields would be instantly rejected as yielding no information. Allowance must be made, of course, for the human element in education. Perfectly valid educational objectives do not always lend themselves to scientific approach, and, even more often, the tests of their attainment can not be administered until the student has been out of college for twenty years and even then not by conventional examinations. Teaching, even the teaching of science, is more of an art than a science and will always remain so. But even after all this has been realized, almost any one would be impressed by the almost complete absence of control on the teaching experiments constituting the long list presented to the committee. Many teachers, especially in colleges, do not realize the extent to which techniques have been developed in recent years, capable of measuring with considerable accuracy the degree to which such aims as can be made explicit are achieved by teaching. Many teaching experiments are fading out in futility solely for lack of the application of perfectly feasible tests by which the results could be demonstrated to others.

During its deliberations the committee found itself facing repeatedly the desirability of the establishment of a central clearing house to which teaching problems in the sciences could be brought for bibliographical aid and for information as to unpublished current ventures in other quarters. Such a bureau could reduce duplication of effort, suggest areas which seemed to be unexplored and in general help to organize and vitalize a phase of science teaching which sadly needs cooperative assistance. The present list of teaching experiments could constitute one of the points of departure for such a bureau. While broadcast publication of that list might do more harm than good, the bureau could put it at the disposal of those who were demonstrably in a position to profit by its use. Another type of working material which the committee would add to the assets of such a bureau would be the bibliography, compiled for the use of the committee, consisting at present of some 600 entries, about half of them annotated. The present indication is that the function of a central clearing house of this nature can be performed by some one of several appropriate agencies already in existence. Arrangements to that end are already under way and when completed will be announced.

There are those who deprecate any suggestion that the mode of presentation of the sciences should be changed to adapt them to the changing requirements of higher education. This attitude seems to be taken partly because the individual is not convinced that the sciences have anything to gain by such a change, and partly through a fear that academic standards will be jeopardized by such a change. Both of these objections are understandable and merit a candid reply.

First, let it be realized that any suggested reformulation of science instruction applies only to a limited portion of the science student body. Only terminal first-year courses are under discussion. We are considering solely the requirements of students for whom the general course will constitute the only experience in that field. Whatever revision in the conduct of preprofessional courses may be appropriate is no concern of the present inquiry. We are dealing only with the reformulation of science instruction for the pur-

[3] See, for example, Constance Warren's new book, "A New Design for Women's Education" (Frederick A. Stokes Company, 1940). The following quotation supports this thesis (page 263): "The medieval cap and gown is not only picturesque, it is too often dangerously symbolic. . . . (College) teaching is the one profession which has never felt the obligation to be abreast of the times."

poses of general education. That is, however, no small undertaking. Thanks partly to the science requirement, it involves the majority of students in the liberal arts.

Second, there is no implication that the science courses, as reformulated for this group of students, should be on an intellectual plane that is one whit lower than that upon which the conventional courses are pitched. On the contrary, any error that is made in judging this level should be on the side of the arts science courses requiring more rather than less ability and application on the part of the student than the pre-professional science courses. An amazing wall of resistance has been built up against experimentation in this field on the assumption that any such venture is necessarily in the direction of relaxation of intellectual standards. The damaging part of that assumption lies in the fact that so many teachers who have ventured into this field have themselves apparently had the same feeling, with the inevitable result that the courses which they have evolved have been open to serious criticism on the basis of their superficiality. Teachers who have taken this position have done a major disservice to the cause which they have been attempting to serve. It should be quite clear that, at a time when any effort in this direction, however meritorious, is bound to come under fire from the conservative element, they have given their critics the best possible ground for the most devastating form of criticism. I can see no escape from the conclusion that mere prudence, if no other factor, must result in pitching any modification of the traditional science courses on a plane well worthy of the mettle of the best students. Any attempt which is based on an assumption that the general level of ability of those who are not expecting to continue with the subject is less than that of those who are, is doomed to ultimate failure.

A third difficulty is perhaps a subhead of the second. It is the feeling that to convert the conventional general course in science to one adapted to general education, about all that needs to be done is to omit some of the more technical material. The whole sorry scheme of starred paragraphs in text-books is an outgrowth of this misapprehension. It should scarcely be necessary to remark that this is attacking the problem at precisely the wrong end. Our students are human beings, candidates for *general* education, before they are engineers or physicists or zoologists, candidates for *professional education*. If the preparation of either is to be the more extensive, it should be that of the candidate for *general* education, with starred paragraphs in *his* text-book to limit it to the narrower requirements of the specialist. It would probably be more discriminating, however, to recognize that each group has its peculiar requirements, and that any attempt to overlap the two, at least without supplementary separate instruction, is certain to prejudice the interests of one group or the other.

This brings us to the main point: What really is the central objective of the sciences as curricular elements in general education? One of the implications of the foregoing paragraph was that science courses for general education should be more extensive than they are usually found to be; that they should give more attention than they now do to the requirements of general education at the college level. It is entirely fair to require any one who subscribes to this assertion to justify it. There is some ground for a contention that the sciences have done very well by themselves through staying in their own technological back yard. Why worry about what the neighbors think? Let us continue (so we are urged) the strategy that has been so productive up to the present. This "isolationist" point of view is very old. Consequently the opinions of many men, both in and out of the sciences, are available on the issue thereby raised. I shall make use of these wherever it seems appropriate.

We live in what is frequently termed the scientific era. General education rightfully looks to the sciences to show why this is a correct characterization and what such a characterization implies. Unless the sciences live up to this responsibility, society will lose sight of the real place of science in the social order. Lord Acton once said:[4]

> There may be, perhaps, a score or two dozen decisive and characteristic views that govern the world, and that every man should master in order to understand his age.

Lord Acton would surely have included a comprehension of the scientific method as one of these views, the one which takes a place of precedence in understanding the present age. Yet how much real comprehension of it does the average educated man possess? R. E. Lee answered the question four years ago in this way:[5]

> In spite of the fact that science has tinged every aspect of the world, the attitude of the man who lives on Main Street toward scientific knowledge is highly capricious and varied. In one breath he proclaims the pure scientist as a highbrow and an impractical theorist; in another he anathematizes him for disturbing the social order and blasphemously undermining his religious beliefs; but at the mention of a name like Edison, he conjures up a sort of superman, before whom he falls in a sort of coma of veneration. At one moment this resident accepts unquestioningly a knowledge he does not fully understand, yet at another he is thrown into a hysteria by the challenge of one of its basic conceptions. Such contradictory mental attitudes may be traced not infrequently to the failure of

[4] Quoted by President Conant. President's Report, p. 10, March 1, 1937.

[5] "Man the Universe Builder," p. 37, Williams and Wilkins, 1935.

individuals to grasp the real *meaning* of science. To be *appreciative* of the merits of science is something more than to be merely *impressed* by its achievements.

One may agree with Lee and yet not concede that it is the proper function of the *sciences* to provide this element of comprehension of the scientific method. There are those who maintain that interpretation of science is the function of philosophy rather than of science itself. This has been tried, however, and found wanting, partly on account of lack of an adequate knowledge, on the part of philosophers, of subject-matter in the fields which they were attempting to interpret, though I suspect that this is not the deepest seat of the trouble. In any case this condition is destined to become worse instead of better as the sciences steadily become more complex. It is growing clear that the interpretive responsibility must be discharged by the sciences themselves if it is to have any chance of being done well. Frederick Barry says:[6]

The ultimate establishment of more liberal elementary courses in science can not be avoided. It is necessary to our purpose that the humanistic liberalization of scientific studies be powerfully advocated and actively encouraged and at once; for the obvious reason that we must depend on the scientists to devise our basic cultural courses in science.

H. D. Gideonse, formerly of Chicago, recently appointed to the presidency of Brooklyn College, remarked a year ago:[7]

Science as usually taught to liberal arts students emphasizes results rather than methods, and tries to teach techniques rather than to give insight into and understanding of, the scientific habit of thought. What is needed, however, is not a dose of metaphysics, but a truly humanistic teaching of science.

We will all admit that we are at present very inadequately trained to make the contribution which Gideonse suggests. We in the colleges are primarily subject-matter specialists and only secondarily educators. This has in large measure been brought about by the adoption of the Ph.D. fetish in higher education, together with the narrowness of the qualifications that graduate schools have established for the doctorate. With the best will in the world, even in the case of one who resolutely puts behind him all conscious consideration of professional recognition and advancement, it is very difficult to give the same heartiness of effort to the non-specialist majority that is spontaneously lavished on the specialist minority. To overcome this tendency will require a pronounced about-face by college teachers of science, but it must be overcome, and our curricular offerings be enriched, if the sciences are to continue as a major factor in the scheme of general education. President Emeritus Neilson has recently said:[8]

Especially in the natural sciences is it the case that the temptation to early and intense specialization has produced a specialist capable of training other specialists, but ill adapted to educating youth between seventeen and twenty-two.

It is still possible for the doubter to demand a bill of particulars. What is the nature of the humanistic element that is thus to be injected into our science teaching? How can it be acquired and transmitted? These, too, are fair questions, but the statute of limitations confines me to a woefully inadequate answer. One could scarcely do justice to the subject in less than a whole address or, better, yet, a whole book. But briefly, of several possible approaches to this problem, the one that impresses me as the most promising is, while retaining substantially the present arrangement of general courses in the sciences and the basic alignment of subject-matter in each course, to place that subject-matter in a setting of the history of its development. In my extremity, let me once more invoke the statements of others on this point.

President Conant recently said:[9]

Much of the significance of accumulated knowledge lies in an understanding of the process by which it was accumulated.

Ernst Mach once said:[10]

The historical investigation of the development of a science is most needful, lest the principles treasured up in it become a system of half-understood prescripts or, worse, a system of prejudices. Historical investigation not only promotes the understanding of that which now is, but also brings new possibilities before us by showing that which exists to be in great measure *conventional* and *accidental*. From the higher point of view at which different paths of thought converge, we may look about us with freer powers of vision and discover routes before unknown.

A. S. Adams asked five years ago:[11]

Can we not lead the student to a greater appreciation of the significance of science by acquainting him with the toilsome thought that has gone into the discovery and confirmation of the scientific facts that we accept so readily? . . . In order to have real meaning, the student's growth in the knowledge of a science must bear some relation to the growth of the science itself.

Wilhelm Ostwald once remarked:[12]

While by the present methods of teaching, a knowledge of science in its present state of advancement is imparted very successfully, eminent and far-sighted men have re-

[6] "The Scientific Habit of Thought," p. 321, Columbia University Press, 1927.

[7] *Bul. Am. Assn. Univ. Profs.*, 24: 376, 1938.

[8] *Bul. Am. Assn. Univ. Profs.*, 25: 591, 1939.

[9] *Bul. Assn. Am. Colls.*, 23: 43, 1937.

[10] "The Science of Mechanics," p. 225, Open Court, 1907.

[11] *Am. Phys. Teacher*, 3: 62, 1935.

[12] Quoted in preface to F. Cajori, "A History of Physics," Macmillan, 1929.

peatedly been obliged to point out a defect which too often attaches to the present scientific education of our youth. It is the absence of the historical sense and the lack of knowledge of the great researches upon which the edifice of science rests.

It should not be invidious to point out that the historical approach is especially appropriate to the teaching of physics and astronomy. It fell to the lot of these sciences to meet the full impact of authoritarianism in the sixteenth and seventeenth centuries. They thus became the focus of the various points of view which converge into the scientific method. But the pattern of thought thereby established became general only because the other sciences moved into their appointed places. The heritage of physics and astronomy belongs as much to biologists and chemists and geologists as to physicists and astronomers. The recognition and exploitation of this heritage is a resource which is being sadly neglected.

One final point: In urging the appropriateness of more emphasis on the historical element in science instruction, I am not suggesting a substitution of the *history* of science for the *study* of science itself. On the contrary, such a venture, to be successful, must hew pretty much to the conventional line of subject-matter already in vogue. But the stage should be set with historical wings and backdrops. As subtopics are taken up in the usual order, the story of their development will shed a new light, not only on their present significance as scientific concepts, but on how they contributed to the birth of the sciences and to the dawning of the scientific era. When the subject is developed in this way, the time involved is not at all proportional to the extra ground covered, since in the main the process consists of rearranging, from another point of view, material already involved or implied in the traditional science courses.

Neither do I take the position that the historical approach is the *only* way in which the sciences can adapt themselves to the requirements of general education which are pressing in on us with ever greater and quite proper insistence. I am sure that there are other ways. But, to me, it seems the solution lying most readily at hand and which can be exploited to the best effect. But whether that method or some other is adopted, a heavy responsibility rests upon college and university teachers of science to adapt their offerings, in one way or another, to the changing requirements of a rapidly evolving educational pattern. The American mass movement toward higher education has no parallel. We have no precedents to guide us. But we shall be wise, perhaps with the wisdom of self-preservation, if we recognize this new responsibility and marshall all our resources to meet it.

SCIENTIFIC EVENTS

CONFERENCES IN BIOCHEMISTRY AT THE UNIVERSITY OF CHICAGO

A group of lecture-conferences in biochemistry, dealing with endocrinology, physiology and the chemistry of vitamins and enzymes, to be held under the auspices of the department of biochemistry of the University of Chicago on June 25, 26 and 27, and on July 9, 10, 15, 16 and 17, has been announced by Dr. E. M. K. Geiling, professor of pharmacology and chairman of the department.

Visiting professors at the summer quarter of the university will conduct the meetings. Among the speakers will be Dr. C. N. H. Long, Sterling professor of physiological chemistry of the School of Medicine of Yale University; Dr. E. A. Doisy, professor of biological chemistry of the St. Louis University School of Medicine, and Professor James B. Sumner, professor of biochemistry of Cornell University Medical College.

The program of the series is as follows:

June 25, 26, 27, Professor Long: Effects of Hypophysectomy and Anterior Pituitary Extracts on Metabolism; Effect of Adrenalectomy and the Adrenal Cortical Hormones on the Metabolism of Carbohydrates and Proteins, and the Interrelationship of the Pancreas, Adrenal Cortex and Anterior Pituitary Cortex as Exemplified by the Study of Experimental and Clinical Diabetes Mellitus.

July 9, 10, Professor Doisy: Vitamin K: Assay, Purification and Isolation; Vitamin K: Constitution of Vitamins K_1 and K_2 and Related Compounds Having Vitamin K Potency.

July 15, 16, 17, Professor Sumner: Development of Present-day Ideas as to the Chemical Nature of Enzymes; the Properties, Preparation and Chemical Nature of Catalase, and Recent Progress in Enzyme Research.

All conferences will be held in Eckhart Hall from 7 to 9 P.M.

HONORARY DEGREES CONFERRED BY NEW YORK UNIVERSITY

Honorary degrees were conferred by New York University on the occasion of its hundred and eighth commencement exercises on June 5 on Dr. N. B. Van Etten, of New York City, president of the American Medical Association; on Dr. John Philip Hogan, president of the American Society of Civil Engineers; on Dr. Gano Dunn, president of the J. G. White Corporation, New York City, and on Dr. Frank Aydelotte, who recently retired as president of Swarthmore College to become head of the Institute for Advanced Study at Princeton, N. J. The candidates were presented to Chancellor Harry Woodburn Chase by the secretary of the university, Harold O. Voorhis. The citations follow:

NATHAN BRISTOL VAN ETTEN

Mr. Voorhis:

Nathan Bristol Van Etten, to-day celebrating his fiftieth anniversary of graduation from our former tributary, Bellevue Medical College, has not only served a full half-century in the general practice of medicine in this city, but extended widely the benefits of his wisdom and experience through high medical executive capacities: President of Morrisania City Hospital and Union Hospital; past-president of the Bronx Borough, Bronx County and New York State Medical Societies, of the Greater New York Medical Association, of the New York Society of Medical Jurisprudence and of the Medical Alumni of this university. Able practitioner and counselor, staunch bulwark against the pandemic threat of quixotic schemes of socialized medicine, he now stands at the threshold of the highest office in the medical profession of this country, the presidency of the American Medical Association. Our prescription for him reads: Doctor of Public Health.

Chancellor Chase:

Nathan Bristol Van Etten, a half century ago you were graduating from what is now the New York University Medical College. To-day you stand here as president-elect of the American Medical Association. The years between have been crowded with achievement. You have taken with high seriousness the oath of your profession. You have been active in promoting the service of that profession to the public good. For what you have done, and for your active pursuit of the ideals you symbolize, we now pronounce you Doctor of Public Health of New York University.

JOHN PHILIP HOGAN

Mr. Voorhis:

President of the American Society of Civil Engineers. For twenty-five years following graduation in arts and science at Harvard, he served this city with conspicuous ability, particularly in the realization of that life-giving miracle, the Catskill Aqueduct. In subsequent professional practice he has become recognized as an outstanding authority on water supply and related problems. As military engineer in France during the first World War, he received many deserved citations and was raised to high command. As vice-president and chief engineer of the New York World's Fair he not only directed its vast and inexorable schedule of construction, but was responsible for the solution of the fundamental problem of giving the water-logged and waste-incrusted meadows of Flushing requisite stability for construction. Engineer extraordinary, he is presented for our honorary Engineering Doctorate.

Chancellor Chase:

John Philip Hogan, in the profession you adorn, none has rendered greater service than you. Your latest achievement is the solution of the difficult engineering problems that were associated with the building of a World's Fair on Flushing Meadow. The verdict of your own colleagues is abundantly evident in your presidency of the American Society of Civil Engineers. In recognition of your great professional services we now name you honorary Doctor of Engineering.

GANO DUNN

Mr. Voorhis:

Native New Yorker, alumnus of City College and of the engineering school at Columbia; president of the J. G. White Engineering Corporation since 1913; past president of the New York Electrical Society, the American Institute of Electrical Engineers and the United Engineering Society; past chairman of the Engineering Foundation and the National Research Council; effective officer and delegate at many international scientific congresses; able counselor of national defence agencies; honored member of a score of distinguished professional and learned societies; valued director and trustee of various banking, industrial and educational establishments; president of the Cooper Union for Advancement of Science and Art; humanist and man of affairs; he is presented for the degree of Doctor of Science.

Chancellor Chase:

Gano Dunn, in the midst of a crowded professional career, the latest achievement of which is the streamlining of the Island of Haiti, you have somehow found time for so many varieties of public service that the mere recounting of them would turn this citation into a biographical essay. These are matters of record for all men to read. You have contributed to education, to business, to national and international affairs, and all your life you have been concerned with the advancement of science in many fields. You are entitled to any honorary degree in the whole category, but we have chosen that of Doctor of Science, which I now confer upon you.

FRANK AYDELOTTE

Mr. Voorhis:

Frank Aydelotte, A.B., Indiana; A.M., Harvard; B.Litt., Oxford; American Secretary to the Rhodes Trustees since 1918, and president for the past ten years of the American Association of Rhodes Scholars; sometime normal and high-school teacher of English and professor of that subject at Indiana University and the Massachusetts Institute of Technology; trustee of leading foundations for the advancement of learning; president of Swarthmore College for the past nineteen years, where he repaired the plumbing, extended the plant, bolstered the endowment, pioneered the "honors" movement among American colleges, sweetened faculty salaries, balanced the budget, and brought tears to the students when he announced last fall his withdrawal to accept the directorship of that crowning citadel of higher education in this country, the Institute for Advanced Study at Princeton; scholar, educator, administrator, author, editor—Doctor of Laws of New York University, if you please, Mr. Chancellor.

Chancellor Chase:

Frank Aydelotte, the degree we give you to-day bears witness both to our recognition of what you have done for the cause of education and to our faith in what, as head of the Institute for Advanced Study, you will be doing over the years that lie ahead. For myself, I hail you as a respected and admired colleague, and with genu-

ine pleasure I confer upon you our degree of Doctor of Laws.

HONORARY DEGREES CONFERRED BY COLUMBIA UNIVERSITY

At the commencement of Columbia University the doctorate of laws was presented to the Marquess of Lothian, British Ambassador to the United States; Associate Justice Stanley F. Reed, of the United States Supreme Court; Dr. Robert L. Stearns, president of the University of Colorado, and Cupertino del Campo, president of the Instituto Cultural Argentino-Norteamericano, Buenos Aires, and the doctorate of letters to Carl Van Doren, editor and author; Harry M. Lydenberg, director of the New York Public Library, and Sidney B. Fay, professor of history at Harvard University.

The degree of doctor of science was conferred on Dr. Alfred E. Cohn, of the Rockefeller Institute for Medical Research; on Dr. Arthur H. Merritt, president of the First District Dental Society of New York; on Dr. Charles K. Leith, professor of geology in the University of Wisconsin; on Dr. Ross G. Harrison, Sterling professor of biology in Yale University; on Dr. Harvey N. Davis, president of Stevens Institute of Technology, and on Dr. William O. Hotchkiss, president of Rensselaer Polytechnic Institute.

The citations were made in the absence of Dr. Butler by Frederick Coykendall, chairman of the board of trustees. For the recipients of the degree of doctor of science they were as follows:

Alfred Einstein Cohn

Member of the Rockefeller Institute for Medical Research; graduated from Columbia College in 1900 and from the College of Physicians and Surgeons four years later; associated since 1911 in most important scientific work at the Rockefeller Institute; counselor and guide for medical research in many fields and under many different authorities, particularly in respect to the treatment of chronic human ailments, notably those of the aging heart and circulatory system; distinguished for the training and guidance of men as well as for the study of disease.

Arthur Hastings Merritt

President of the First District Dental Society of New York; graduated with highest honors from the New York College of Dentistry in 1895 and entering at once upon the practice of his chosen profession; giving particular attention to research in the field of periodontia with most fortunate and helpful results for his fellow men; highly honored both at home and abroad for his scientific achievements.

Charles Kenneth Leith

Professor of geology at the University of Wisconsin; a distinguished son of Wisconsin and graduate of its university; turning at once to geology as a field of instruction and research; putting his rich knowledge at the service of the government on many important occasions; notably honored at home and abroad for his scientific leadership and inspiration in the field of economic geology, especially in all that relates to the economic aspects of the vast iron industry.

Ross Granville Harrison

Sterling professor of biology in Yale University; trained at Johns Hopkins University in its early years and then at the University of Bonn; entering at once upon that vitally important field of study and research which he has since cultivated with brilliant distinction; climbing one rung after another of the ladder of scientific advancement until he is now hailed on both sides of the Atlantic as one of the world's outstanding biologists and leaders of scientific thought.

Harvey Nathaniel Davis

President of Stevens Institute of Technology; after student days at Brown and Harvard Universities, choosing a career in which he has been highly successful as a teacher and research worker in the field of mechanical engineering, especially as to all which deals with the properties of steam; president of Stevens Institute of Technology since 1928; who well illustrates the saying of Oliver Wendell Holmes that science is a first-rate piece of furniture for a man's upper chamber if he has common sense on the ground floor.

William Otis Hotchkiss

President of Rensselaer Polytechnic Institute; another distinguished son of Wisconsin and educated at its honored State University; working successfully in mining, his chosen field of geological study; made state geologist of Wisconsin in 1909, and elected president of the Michigan College of Mining and Technology in 1925; now serving with distinction as president of the Rensselaer Polytechnic Institute, our oldest school of engineering.

DINNER IN HONOR OF PROFESSOR McCLUNG

A dinner in honor of Dr. C. E. McClung, professor of zoology and director of the zoological laboratory of the University of Pennsylvania, was held on the evening of June 1 at the Hotel Philadelphian, in Philadelphia. The dinner was attended by more than a hundred and fifty colleagues, former students and other friends. Dr. George William McClelland, provost of the university, acted as toastmaster. The speakers included: Professor Wyman Green, of Drew University; Dr. John C. Johnson, director of the Rocky Mountain Biological Laboratory, and the following from the University of Pennsylvania: Provost Emeritus J. H. Penniman; Emeritus Professors of Zoology P. P. Calvert and J. P. Moore; Emeritus Professor of History E. P. Cheyney; H. Lamar Crosby, formerly dean of the Graduate School; and Dr. A. N. Richards, vice-president in charge of medical affairs. Presentations were made by D. H. Wenrich, professor of zoology. To Dr. McClung were presented a bound copy of Volume 66 of the *Journal of Morphology,*

which has been published in his honor, a "McClung Model" research microscope and a book of greetings. His portrait was unveiled and presented to the university.

The book of greetings was bound by hand in a hand-tooled leather cover and had an illuminated frontispiece bearing the inscription: "Greetings and Felicitations to Clarence Erwin McClung from Those Who Consider it a Privilege to Know Him as Teacher, Colleague and Friend." It contained more than two hundred letters sent from all parts of this country and from South America, Japan, China, India, South Africa and various European countries.

In his response Dr. McClung spoke briefly and feelingly of his appreciation of the sentiments and events of the evening.

RECENT DEATHS

JOANNES GREGORIUS DUSSER DE BARENNE, since 1930 Sterling professor of physiology at Yale University, died on June 9 at the age of fifty-five years.

DR. DAVID RIESMAN, professor of the history of medicine in the Graduate School of Medicine of the University of Pennsylvania, died on June 3, at the age of seventy-three years. He had been connected with the medical school since 1897.

DR. WILLIAM E. HARPER, director of the Dominion Astrophysical Observatory at Victoria, B. C., died on June 4. Dr. Harper was sixty-two years old.

DR. C. L. BOULENGER, professor of zoology at Bedford College, University of London, died on May 19 at the age of fifty-five years.

SCIENTIFIC NOTES AND NEWS

THE honorary degrees conferred by the Johns Hopkins University at its commencement on June 4 included the doctorate of laws on Dr. Vannevar Bush, president of the Carnegie Institution of Washington, and on Dr. Edwin Grant Conklin, executive vice-president of the American Philosophical Society and professor emeritus of zoology at Princeton University. Dr. Isaiah Bowman, president of the university, delivered the commencement address.

DR. CHARLES F. KETTERING, president of the General Motors Research Corporation, was prevented by work for the War Defense Board from being present to receive the honorary degree of doctor of science at the commencement exercises on June 9 of Rutgers University.

THE doctorate of science was conferred on Jason John Nassau, professor of astronomy and director of the Warner and Swasey Observatory of the Case School of Applied Science at Cleveland, at the commencement of Syracuse University. Owen D. Young, honorary chairman of the board of directors of the General Electric Company, who made the commencement address, received the degree of doctor of laws.

DR. LUTHER P. EISENHART, professor of mathematics and dean of the Graduate School of Princeton University, received the doctorate of laws from Duke University on June 3.

AT the one hundred and fifth commencement of Albion College held on June 3 Harvey Newton Ott, for twenty years president of the Spencer Lens Company, was awarded the honorary degree of doctor of science. The citation by President John L. Seaton read in part as follows: "Leader with another honored Albionian in the development of the great Spencer Lens Company of Buffalo; noted as an inventor of many mechanical improvements on microscopes; known to laboratory workers everywhere as a highly skilled designer of microtomes and other instruments of precision indispensable in research and the progress of science."

IN recognition of the services that David Sarnoff, president of the Radio Corporation of America, has rendered in the advancement of the science and industry of radio, the president of the French Republic has conferred upon him the decoration of Officer of the Legion of Honor, elevating him from the rank of chevalier which he has held since 1935. The decoration was presented to Mr. Sarnoff on June 6 by the French Consul General in New York, Count Charles de Ferry de Fontnouvelle, in whose office the ceremony took place.

THE 1940 Trudeau Medal of the National Tuberculosis Association has been awarded to Dr. Wm. Charles White for distinguished service in tuberculosis. Dr. White is chairman of the Division of Educational Relations of the National Research Council and consulting pathologist of the United States Public Health Service.

DR. GEORGE W. CORNER, professor of anatomy at the University of Rochester, was presented on June 10 with the first Squibb award of $1,000 for research in endocrinology at the annual dinner of the Association for the Study of Internal Secretions meeting in New York City. The award was established by E. R. Squibb and Sons.

AT the New York meeting of the American Association of Industrial Physicians and Surgeons on May 27, the annual William S. Knudsen award "for outstanding achievement in industrial medicine" was presented in recognition of advances in the knowledge of silicosis resulting from research directed by him to

Dr. Leroy U. Gardner, director of the Saranac Laboratory for the Study of Tuberculosis of the Edward L. Trudeau Foundation.

DR. GEORGE WASHINGTON CARVER, head of the department of agricultural chemistry at Tuskegee Institute, Alabama, on June 2 at the Hotel Pennsylvania, New York City, received the award of a bronze plaque commemorating his "brilliant achievements" from the International Federation of Architects, Engineers, Chemists and Technicians, a C. I. O. affiliate. The presentation was made by Dr. Franz Boas, professor emeritus of anthropology at Columbia University. The plaque was accepted by Dr. A. W. Curtis, Jr., research assistant to Dr. Carver, who was unable to attend.

DR. PAUL P. MCCAIN, of Sanatorium, N. C., was elected president of the National Tuberculosis Association at the thirty-sixth annual meeting, held recently in Cleveland.

DR. FRED ALBEE, of New York, was elected on June 8 president of the International College of Surgeons. Dr. Desiderio Roman, of Philadelphia, was elected president of the United States chapter of the organization. The United States chapter and the governing council decided to transfer headquarters from Geneva to Washington for the duration of the war.

DR. LAIGNEL-LAVASTINE, professor of the history of medicine at the University of Paris and a well-known medical historian, has been elected president of the Société Médicale des Hôpitaux de Paris for 1940, in succession to Professor Pierre Lereboullet.

INSTALLATION ceremonies of the University of Southern California Chapter of the Society of the Sigma Xi were conducted on May 24 by Dr. George A. Baitsell, professor of biology at Yale University, national secretary and past president, assisted by Dr. Carl D. Anderson, professor of physics at the California Institute of Technology, a member of the National Executive Committee. The award of the charter to the University of Southern California brings the number of chapters to sixty-nine. Officers elected for the year are: *President,* Dr. Harry James Deuel, professor of biochemistry; *Vice-president,* Dr. Robert Evans Vivian, professor of chemical engineering; *Secretary,* Dr. Francis Marsh Baldwin, professor of zoology, and *Treasurer,* Dr. Arthur Wickes Nye, professor of physics.

THE Case Chapter of the Society of the Sigma Xi held its annual initiation on the evening of May 31. Two faculty members and twenty-seven students were elected to full membership. Officers elected for the coming year are: Professor R. S. Shankland, *president;* Professor Paul L. Hoover, *vice-president;* Dean T. M. Focke, *treasurer;* Professor Richard S. Burington, *secretary.* Following the ceremonies, at which Professor F. M. Whitacre, retiring president, presided, Ray P. Dinsmore, of the Goodyear Tire and Rubber Company, Akron, spoke on the "Romance of Rubber."

PROFESSOR J. L. COOLIDGE, since 1918 professor of mathematics at Harvard University and since 1929 master of Lowell House, will retire from both positions with the title emeritus on September 1. He has been a member of the department of mathematics for forty years.

THE title of emeritus professor of mathematics has been conferred on Dr. Arnold Emch, of the University of Illinois, who joined the department of mathematics as assistant professor in 1911 and was appointed to a professorship in 1927.

WILBUR C. NELSON, aeronautical engineer with Engineering Projects of Dayton, Ohio, has been appointed assistant professor of mechanical engineering at the Iowa State College. He will be in charge of aeronautical instruction to succeed Colonel W. A. Bevan.

DR. C. A. BUEHLER, professor of chemistry at the University of Tennessee, will become head of the department of chemistry on July 1.

DR. DIRAN H. TOMBOULIAN has been appointed assistant professor of physics at Cornell University; Dr. Robert F. Bacher, now assistant professor of physics, has been advanced to the rank of associate professor.

DR. S. S. GOLDWATER, commissioner of hospitals, has accepted the presidency of the Associated Hospital Service (the 3c-a-day plan), of New York. More than a million and a quarter subscribers belong to the plan. Approximately four hundred of these subscribers are admitted daily to hospitals for necessary hospital services. Payments to hospitals are now being made at the rate of $8,000,000 a year.

W. B. VAN ARSDEL has been appointed chief of the Engineering and Development Division of the Western Regional Research Laboratory of the U. S. Department of Agriculture at Albany, Calif. Mr. Van Arsdel will conduct the engineering development of processes worked out in the laboratory, and will make a study of industrial opportunities for expanding outlets of farm products.

THE American Pharmaceutical Association has elected Dr. Robert P. Fischelis, secretary and chief chemist of the Board of Pharmacy of the State of New Jersey, to serve for the next six years as one of its three representatives on the American Council of Pharmaceutical Education. This council is the national accrediting agency for Colleges of Pharmacy.

AN executive committee, composed of Professor Richard C. Tolman, Dr. Max Mason and Professor E. C. Watson, has been appointed by the trustees of the California Institute of Technology to provide means of mobilizing and coordinating effort in the present national situation. The council will proceed immediately with a survey of the possible contributions which the institute can make both through individual members of the staff and special facilities in the laboratories. All members of the committee were active in warfare service in 1918. Experts in fields of military significance have offered to devote a large portion of their time to defense work.

SIR WILLIAM BRAGG, president of the Royal Society, has been appointed president of a scientific food committee formed to estimate the food requirements of Great Britain and how to fill them during the present emergency.

DR. WILLIAM E. WICKENDEN, president of the Case School of Applied Science, Cleveland, will deliver the address at the eighty-first commencement on June 16 of Cooper Union, New York City. The exercises will be presided over by Dr. Gano Dunn, president of the union.

DR. SELMAN A. WAKSMAN, professor of soil microbiology at Rutgers University, gave an address on "Microbes in a Changing World" at the general session of the Florida Soil Science Society at its recent meeting at the University of Florida on May 29.

THE eighty-eighth annual meeting of the Society for the Promotion of Engineering Education will be held at the University of California from June 24 to 28. An honorary reception committee has been appointed, of which Professor Charles Derleth, Jr., dean of the College of Engineering, is chairman.

AN American Society of Agricultural Sciences, which will represent the American republics, has been organized. The society was formed in response to a recommendation of the eighth American Scientific Congress, which recently met in Washington. It was organized by delegates from twelve countries. The objects of the society are "To recognize agriculture as a basic industry of the Americas—a close tie between the American republics; to advance scientific agriculture in the republics through individual and collective effort; to provide a central organization for coordination of the agricultural sciences; to hold meetings, issue publications and otherwise disseminate agricultural information; to provide for exchange of research findings, ideas and experiences among members and to promote friendship among workers in agricultural sciences in the American republics."

AT the Harrison, N. Y., meeting of the American Laryngological Association the society made an offer to the Government of the medical services of its members in case of this country's involvement in war. The offer was without restrictions. It agreed that its members would, at the request of the Army, Navy or Air Corps, relinquish private practice and serve either individually or collectively as government physicians.

THE Federal District Court has ordered the arraignment on June 14 of the American Medical Association and several of its officers on charges of violating anti-trust laws. The order followed the Supreme Court's refusal to hear the plea of the association for exemption from the Sherman Anti-Trust Act on the ground that doctors were not engaged in "trade" within the meaning of the law.

AT the alumni day dinner of the Massachusetts Institute of Technology on June 3, Dr. Karl T. Compton, president of the institute, announced that a gift of $200,000 had been received from the Rockefeller Foundation for the initiation of a program of research and education in biological engineering, and a gift of $100,000 from Alfred P. Sloan, Jr., chairman of the board of the General Motors Corporation, for the expansion of research for national defense. The gift will be used for the construction of a large addition to the airplane engine laboratory, making possible an increase in the effectiveness of its contribution to the national program of aircraft design and production.

GIFTS to the Field Museum of Natural History, Chicago, include 731 specimens of exotic birds from Melvin Traylor, Jr., of Chicago. These were collected on a recent expedition to Yucatan and Campeche, Mexico. The library of the museum has received also a gift of a hundred volumes from Dr. Henry Field.

THE National Forest Reservation Commission has approved the purchase of 132,217 acres of land for national forests in twenty-five states. The land will become part of fifty-one of the 196 national forests and purchase units. The total purchase price was $601,740. Since the first of the year, the commission has sanctioned the buying of 391,485 acres at a cost of $1,545,666.

THE department of physics at the University of Pittsburgh announces special graduate courses to be given in the summer session, from June 17 to July 26. These are on the physics of metals, given by Dr. Lee A. DuBridge, University of Rochester; Dr. R. P. Johnson, General Electric Company; Dr. W. V. Houston, California Institute of Technology; Dr. Frederick Seitz, University of Pennsylvania; Dr. B. E. Warren, Massachusetts Institute of Technology, and Dr. S. S. Sidhu, University of Pittsburgh; on the physics of glasses by Dr. Warren, and on nuclear

hysics by Dr. DuBridge and Dr. A. J. Allen, Uniersity of Pittsburgh. There will be a seminar in uclear physics conducted by Dr. E. U. Condon, Vestinghouse Research Laboratories. Further information can be obtained by writing to the head of he department of physics.

THE fourth national conference in recent years of mall Fruits Breeders was held on April 26 and 27 n Eastern North Carolina. April 26 was spent at he North Carolina Coastal Plain Station at Willard, tudying selections, varieties, selfed lines and outrosses of strawberries; crosses of a number of Asiatic species of raspberries, and crosses for thornless and high-flavored blackberries and dewberries. In the evening Dean I. O. Schaub, of the North Carolina Station, presided at a round table conference at Wilmington. April 27 was spent in visiting the blueberry fields and breeding work at the Huntington planting at Atkinson and at the Crabbe planting at Magnolia. The breeding work visited is cooperative between the United States Department of Agriculture and the North Carolina Experiment Station. About thirty-five workers attended the conference, representing states from Maine to California.

DISCUSSION

UNDAMENTAL LAWS OF OPERATIONS IN MATHEMATICS

ONE of the primary facts in the history of matheatics is the late appearance in the literature of this ubject of special names for the laws of the fundaental operations of mathematics which are now comonly called the associative law, the commutative law nd the distributive law, respectively. No evidence of name for any one of these laws before the beginning f the nineteenth century has yet been published, owithstanding the fact that all of them relate to the lementary operations with positive integers and hence o our oldest extant mathematical literature. The assoiative law might with good reasons be called the arenthesis law, since it asserts that an arbitrary numer of the terms or factors which are to be combined y the same operation may be inclosed within a parenhesis and the terms or factors within the parentheses ay then be combined separately into single terms or actors without affecting the final result.

Without giving a special name to this law it was oted by A. M. Legendre in his well-known "Essay ur la théorie des nombres," page 3 (1798), and it was xplained quite fully by another French writer, J. D. ergonne, in volume 1, pages 52–58 of the influential arly mathematical periodical entitled *Annales de athématiques,* which appeared in 22 volumes (1810–831) and is sometimes still called Gergonne's *Annales.* n this article Gergonne directed attention to the now ell-known fact that for real numbers the associative aw can be explained by means of a rectangular parallelepiped, since the volume of such a figure is the roduct of its base into its altitude and the base can e selected in six different ways. Similarly, the comutative law can be explained by means of a rectangle. he *term* associative law was introduced by the noted rish mathematician, W. R. Hamilton (1805–1865), ho used it frequently in his writings on quaternions nd emphasized its importance.

The now common terms commutative law and disributive law were frequently employed by F. J. Servois in an article published in Gergonne's *Annales,* volume 5 (1814), which its author called an extract, in substance, of works presented by him earlier to the French Institut, but which this Institut does not seem to have published. What may be of most interest in connection with these concepts is that they were named so recently. The commutative law and the distributive law in multiplication were noted already in Euclid's "Elements," but Euclid did not then use any special names in connection with these fundamental laws. His example was followed for more than two thousand years by later writers on mathematics. This is the more remarkable in view of the fact that the first proposition of Euclid's "Elements" relates to the equilateral triangle which is now commonly known to be transformed into itself by some non-commutative movements.

In the article under the entry "Number" in the "Encyclopaedia Britannica" (1938) it is stated that there are five fundamental laws of operation, *viz.,* two commutative laws, two associative laws and one distributive law. The commutative law of addition and the commutative law of multiplication are commonly regarded in the mathematical literature as the same law, but they are here regarded as two laws. Similar remarks apply to the associative law of addition and the associative law of multiplication. The nomenclature in this encyclopedia may be compared with the one employed in Zassenhaus's "Lehrbuch der Gruppentheorie," volume 1 (1937), in which the author lists one associative and one commutative law, but two distributive laws on page 62, *viz.,* a right distributive law and a left distributive law.

If one would say that the commutative and the associative laws should be said to change with the subjects to which they are applied there would evidently be no upper limit to the number of these fundamental laws, but it is difficult to see that anything could be gained by the use of such an unnecessarily complex nomenclature. At any rate it would appear desirable that an author who deviates from the common nomenclature should give some reasons for this deviation so that the

reader might not be confused by the differences in the language. This seems especially true with respect to articles which appear in standard works of reference which are supposed to be largely consulted by those who do not claim to be experts on the various subjects on which they seek some information.

It would obviously be puerile to aim to direct public attention to all the definite errors which one may observe in the literature, but blemishes in works which are widely regarded as authoritative like the "Encyclopaedia Britannica" and which are frequently revised deserve wide publicity in order that their harmfulness may be mitigated and that the public may remain duly watchful as regards shortcomings. The careful study of errors is sometimes an attractive method for securing a clear insight into a subject. It may be added that by consulting the article under the entry "Quaternions" in the encyclopedia in question it will be seen that this encyclopedia is not entirely consistent with respect to the number of commutative and associative laws of operation in mathematics.

G. A. MILLER

UNIVERSITY OF ILLINOIS

STABILITY IN NOMENCLATURE

MANY plant taxonomists, in recent years, have contemplated the idea of a new series of beginning dates for botanical nomenclature; one of the latest of these proposals to appear in print is that of Wheeler.[1] The author of this proposal suggests that a series of uniform monographs should be executed with strict regard for the rules of botanical nomenclature and the type concept and thereafter accepted as a new starting date for the nomenclature of the group treated. Such a procedure, it is hoped, would produce stability in nomenclature and eliminate the present accumulation of useless synonymy.

That any international congress will seriously consider adopting such a proposal is extremely unlikely, but before the matter goes beyond its present nebulous stage it may be well to discuss the desirability of any such change in our present system, which accepts the publication of Linnaeus' "Species Plantarum" in 1753 as a beginning date for nomenclature of the higher plants. It is the opinion of the present writer that any such change in our system would increase, rather than reduce, the present confusion.

The most obvious objection to the proposed change is its utter impracticability. What "international body of systematists" is capable of passing judgment upon any modern monograph? In theory, at least, the author of such a monograph is the sole person capable of judging it; if his conclusions are to be questioned, such questioning can be done only by another monographer who has spent at least as much time and effort upon the group as the original author. Therefore, before any monograph is acceptable to the appointed committee on approval, the committee must go over the original sources available to the monographer. As these sources are diverse, comprising exhaustive herbarium, field and library study, the committee would in each case have to prepare its own monograph in order to be sure that the original was acceptable. And even after the second monograph had been finished, what sincere student would accept its conclusions without himself checking the sources of information?

But let us suppose that a monograph is approved by an international group of systematists whose approval is accepted as the final word. Now it becomes unnecessary for future students to examine the earlier literature of the group, at least in so far as nomenclature is concerned. The synonymy in the group has become frozen; all names thrown into synonymy by the monographer become essentially outlawed. This, in effect, is precisely what happens under our present system when a monograph obtains universal recognition. The casual student, who suspects that he has a new species, does not go further back than the best available monograph, and this casual student is not to be affected by the proposed change in the system. It is the future monographer who will find himself at a loss. In view of the more abundant material available to him than to the original monographer, or as a result of improved criteria, he may decide that a dozen species were lumped as one by his predecessor. Shall he give his own names to eleven of them, even if they all have earlier and outlawed names? In cases of change in generic concept (and such concepts are certain to change from time to time) our future monographer will find himself in even more of a moral dilemma.

Wheeler admits that "there are many problems to solve before any plan for a new beginning date can be put into operation, but *now* is the time to begin." I question whether such a beginning should ever be made. What is fundamentally wrong with our present system? It is no hardship to the careful monographer to examine all previous work on his group and pass judgment upon it; in fact, any monographer worthy of the name will continue to do this in spite of legislation. It is no hardship to the casual student, who need not go beyond the best available monograph for his facts. If the next international congress wishes to appoint a committee to list the best available monographs in each group, such a list would certainly be useful, but in the opinion of the writer it should never, at whatever distant time, be legislated into a formal beginning date.

Perhaps the writer is too optimistic in believing that the present confusion in nomenclature will be decreased without legislation. But it seems to him that the situation is becoming clarified with every careful mono-

[1] L. C. Wheeler, *Am. Jour. Bot.*, 26. Suppl.: 25s. 1939.

raph. The classification of plants is a young field of uman endeavor; if stability has not been achieved in e few years since 1753, that is no reason to legislate ability at the sacrifice of accuracy. That we have ccepted 1753 as a beginning date (instead of Adam, s at least one of our number has proposed) is sufficient f a compromise. Would it not be well to let the resent system have a fair trial, let us say another ousand years?

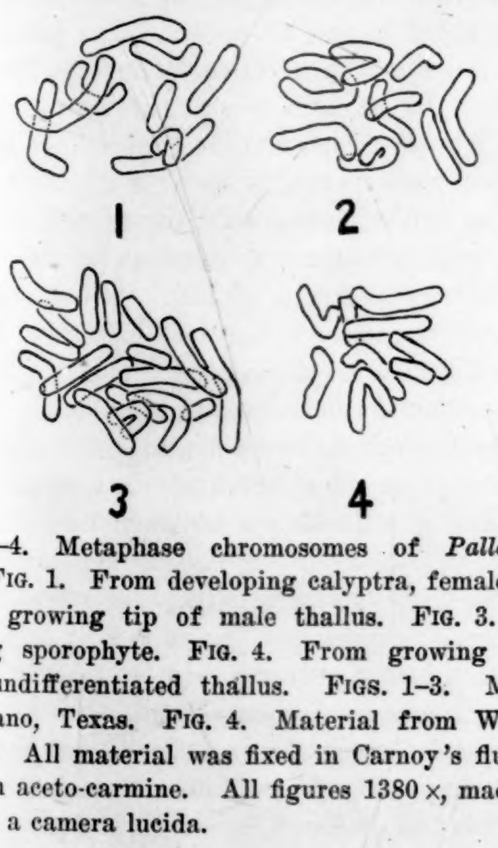
A. C. SMITH

NEW YORK BOTANICAL GARDEN

ANEUPLOIDY IN A HEPATIC SPECIES

INTRA-SPECIFIC aneuploidy in the Hepaticae has een reported by Haupt[1] in *Marchantia* species. The lants studied were hyperhaploids having one or more upernumerary chromosomes.

The chromosome number for the anacrogynous epatic *Pallavicinia Lyellii* (Hook.) S. F. Gray has een established as $n = 8$, $2n = 16$ by Moore,[2] Tatuno,[3] nd Wolcott.[4] Male and female gametophytes of *P. yellii* collected near Milano, Texas, have recently been nvestigated. These plants have 9 chromosomes (Figs. 1, 2). Developing sporophytes from the same location



FIGS. 1–4. Metaphase chromosomes of *Pallavicinia yellii*. FIG. 1. From developing calyptra, female. FIG. . From growing tip of male thallus. FIG. 3. From eveloping sporophyte. FIG. 4. From growing tip of exually undifferentiated thallus. FIGS. 1–3. Material rom Milano, Texas. FIG. 4. Material from Wilmington, N. C. All material was fixed in Carnoy's fluid and meared in aceto-carmine. All figures 1380 ×, made with he aid of a camera lucida.

ossess 18 chromosomes (Fig. 3). A haploid count of was also made in sexually undifferentiated thalli rom Wilmington, North Carolina (Fig. 4). These two clones are then hyper-haploid. In the Texas material further investigations are being made to identify the extra chromosome.

An explanation of the origin of the aneuploid forms of *P. Lyellii* may be found in nuclear behavior during meiosis and spore formation. Since the aneuploid races were found during the past summer and meiosis takes place in *Pallavicinia* in March, no such investigation has been possible in aneuploids. However, in *P. Lyellii* ($n = 8$, $2n = 16$) from Charlottesville, Virginia irregular meiosis is present as evidenced by occasional chromatin bridges during anaphase I and an uneven distribution of the chromosomes during telophase II. Following spore formation restitution nuclei and fragmented nuclei are seen. These observations (unpublished data) indicate the possibility of the formation of spores with aberrant chromosome numbers.

G. B. WOLCOTT

SOUTHWESTERN UNIVERSITY, TEXAS

[1] Gertraud Haupt, *Zeits. Indukt. Abstamm.-Vererungsl.*, 62: 367–428, 1933.

[2] A. C. Moore, *Bot. Gaz.*, 36: 384–388, 1903.

[3] S. Tatuno, *Jour. Sci. Hiroshima Univ. Ser. B*, Div. 2, : 1–9, 1936.

[4] G. B. Wolcott, *Amer. Jour. Bot.*, 24: 30–33, 1937.

EATING OF BONE BY THE PREGNANT AND LACTATING GRAY SQUIRREL

SINCE October, 1939, I have observed almost daily a group of five gray squirrels in my city back yard. A pair of them made a nest and wintered in one of the trees in the yard. I and neighbors feed them peanuts, various varieties of nuts and acorns. When the female became pregnant in the spring she began to eat, daily, old dried bone, some of the bones having been in the soil for from one to three years, and hence had lost all or nearly all animal flavor. At no time before the pregnancy did I observe this female eating bone. The males and the younger non-pregnant females have not been observed eating bones. This looks like a special "urge" or appetite for calcium and phosphorus during pregnancy and lactation in this species. But, of course, this is not established by this isolated observation. I should like to know whether others have noted this phenomena in the gray squirrel or related species, especially where these animals are kept in captivity.

There is evidence that some of the lower mammals and birds have some type of physiologic guide to an adequate diet, a guide or urge not clearly present in the human species, at least not in the adults. The pregnant or lactating mammal needs more calcium and phosphorus than the non-pregnant. But how is that need expressed in the animal's nervous system so that it leads to eating dried bones? There is abundant evidence of pregnancy inducing variations or fickleness of the appetite in the human species. But I know of no evidence of the appearance of a conscious urge (as distinct from knowledge) for the ingestion of more of the bone-forming salts during pregnancy and lactation.

A. J. CARLSON

UNIVERSITY OF CHICAGO

SCIENTIFIC BOOKS

COSMIC RAYS

Cosmic Rays. By R. A. MILLIKAN. viii + 134 pp., 42 figs. New York: The Macmillan Company; Cambridge, England: The University Press. 1939.

THIS book grew out of three lectures, presumably of a popular nature, delivered in the University of Virginia in 1936, revised and delivered in Dublin in 1937, scientifically extended and published in 1939. Owing to the manner in which the book originated, it was not intended by Dr. Millikan that it should be regarded as a complete scientific text on cosmic rays. Yet it is an important human document, for it shows on the one hand Dr. Millikan in action as he states his views on social problems, and on the other as he presents the accumulation of evidence which may lead us to understand this mysterious cosmic phenomenon.

In the first chapter Dr. Millikan considers the value of science in human affairs. Necessity compels him to be brief. Had he wished he could have pointed out the amplification of the man power of a nation by the utilization of the energy of coal and water fall—an amplification of about 5,000 for the United States. He could have shown that modern industry, even modern warfare, is applied modern science. But he introduces this topic apparently to justify the idea that "the influence of great scientific discoveries . . . provides for the system of free enterprise." "Ideas are more potent than machines in determining the direction of human evolution and the fate of empires." He might have gone back to the year 1215 and the Magna Charta for support of this verdict, although in that case the influence of science was not impressive. Yet in this scientific age, and indeed in the enlightened land in which we live, Dr. Millikan finds some ideas not to his liking. These ideas are decidedly not due to cosmic phenomena, in fact, some of them flourish best in the progressive state of California. Many people there look upon the "ham and eggs" ideas as "sun kissed," but one infers that Dr. Millikan regards them as *moon-struck* or *ideas due to sunstroke.* (These terms are the reviewer's.) The author also seems to be under the impression that we can not acquire wealth by drowning a million pigs in the Mississippi. Though he does not say so, one infers that he would welcome a more scientific spirit in our government. "Scientists and engineers are always reactionaries—because they have learned by life-long experience that they can not improve bridge building and ignore the fundamental laws of structures which have already been discovered."

Having expressed himself vigorously regarding certain social or anti-social views, Dr. Millikan then deals with a few elementary physical topics—radiation, wavelengths, frequencies, photons, x-rays, radioactivity; he shows that the energies of particles or photons may be measured in terms of electron volts. The very early history of cosmic rays (up to 1922) is treated in one page. Then naturally and reasonably the work of Millikan and Bowen, Cameron, Neher, Anderson and Neddermeyer—the Pasadena School—fills nearly the rest of the book, but not to the exclusion of other important contributions.

The phenomena connected with cosmic rays are vast and exceedingly complex. The contributions to our knowledge of these phenomena made by the Pasadena workers are many and basic, but they are not the only ones. The discovery of the positron and, with substantial support from other workers, the discovery of the mesotron give to Anderson and Neddermeyer a premier place. The many beautiful cloud-track photographs in this book have been taken by Dr. Millikan's associates.

What are cosmic rays? The term implies that they are rays—particles or photons—which come to the earth from the vastly distant realms of space. But nearly all the phenomena which we see on the earth's surface and even for miles above the surface are due to secondaries originating in our atmosphere or secondaries raised to the *n*th power. The primary particles bombard matter, secondaries result. The process continues. Dr. Millikan does not always make it clear that he is presenting data in regard to secondaries. (The cloud-track photographs make it clear that this may be so.) Yet he is constantly striving to solve at once the riddle of the universe—what are the primaries, where and why do they originate? It would appear, in the light of experience since 1922, that it might be well to hold these questions in abeyance and to content ourselves with the more prosaic details of measuring the many characteristics of the so-called cosmic rays, ionization, penetration, curvature in a magnetic field, production of electron pairs, production of showers, intensity variation due to the earth's magnetic field (latitude effect), and due to altitude, variation due to atmospheric temperature (at all levels!). It was in this way that Clay discovered the latitude effect—a discovery that was discounted until Compton and his many associates completely affirmed his results. In this way Johnson and Street discovered that more particles come from the west than from the east, especially near the (magnetic) equator and at high altitudes (Johnson). These experiments prove that not only are electrified particles coming in the atmosphere but that there is a preponderance of positives. Dr. Millikan deals with all these details, although other writers might change the emphasis both with regard to the discovery and the discoverer.

The last two of the three chapters of the book are rather technical. Very especially is this so when Dr. Millikan discusses the Bethe-Heitler law of absorption

of photons and electrons, the energy regions in which it holds and does not hold. To follow the presentation along this line would lead us into a technical discussion.

The great contribution of the past three years in the realm of cosmic rays has been the discovery of the mesotron (meson, barytron, heavy electron). Of course we are shown the historic and unique photograph made by Neddermeyer and Anderson of the cloud track of a dying mesotron. But the very important photograph obtained by Street and Stevenson is not shown. In this photograph there are two tracks, one undoubtedly made by a proton, the other by the unknown particle. The curvature and ionization for each track are measured. A simple computation makes the mass of the unknown particle about 130 times that of an electron. Various observers have found ratios ranging from 100 to 800. Is there only one mesotron? What was it before it started on its brief (one millionth of a second) career of plunging with vast energy (200,000,000,000 electron volts?) through great thicknesses of matter? What does it become when it vanishes in thin air? This kind of question must in part be answered before we can hope to solve the riddle of the how, why and when of the origin of the primary cosmic rays.

GORDON FERRIE HULL

DARTMOUTH COLLEGE

NON-UNIFORM GASES

The Mathematical Theory of Non-Uniform Gases. By S. CHAPMAN and T. G. COWLING. pp. xxiii + 404. Cambridge: University Press. New York: The Macmillan Company. $7.50.

THE scope of kinetic theory is defined by the authors as follows: "It is the province of a detailed kinetic theory to study the problems of non-equilibrium states, and such investigations occupy the greater part of this book. The probability methods of the kinetic theory are also, however, in the earlier chapters (3 and 4) applied to determine the equilibrium states; the results thus obtained are merely special cases of much more general results of statistical mechanics." The scope of this book is, however, further restricted to gases of medium density. Low densities, where collisions with the walls of the containing vessel are important, are not treated. An account of Enskog's work on dense gases is given in Chapter 16. In this work Enskog considered the collisions of smooth rigid elastic spherical molecules of finite size. Thus the space-filling property of molecules was taken into account, but not multiple collisions. These have not yet been considered in kinetic theory except by Wiener.[1] The scope is also limited to the mathematical theory. Thus the thermal diffusion coefficient is calculated and shown to be small, but experimental arrangements which multiply the effect of thermal diffusion so as to produce very good isotope separations are not discussed.

Within its scope the book is excellent. The fundamental equations of the subject were given by Maxwell and Boltzmann (1866 and 1872). They were first solved for the general case by Chapman and Enskog in 1916 and 1917 in papers often referred to but not often read. Chapman is senior author of this book, and the method used is that of Enskog, which is presented both clearly and rigorously for the first time. The distribution function is expanded in a convergent series, Sonine Polynomials forming an interesting part of the expansions. General formulae are thus obtained for the viscosity, thermal conduction, and diffusion coefficients. Special molecular models are considered. They are mostly spherically symmetrical force fields. When introduced in the general formulae they yield numerical results which are compared with experiments. Suitable choices of the fields are shown to give excellent agreement. The more direct atomic ray measurements of the force fields are not mentioned.

Ionized gases are considered in the last chapter, the effect of crossed electric and magnetic fields being studied quite thoroughly. Crossed concentration gradient and electric field, such as occurs when electrons are drawn through a slit into a gas, is, however, not treated.

The book is addressed to the theoretical physicist, as may be gathered from the 329 symbols listed at the beginning. To one interested in kinetic theory it should be essential.

WILLIAM PHELPS ALLIS

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

SOCIETIES AND MEETINGS

THE NORTH CAROLINA ACADEMY OF SCIENCE

THE thirty-ninth annual meeting of the North Carolina Academy of Science was held at Davidson College on May 3 and 4, 1940. Some two hundred members registered. About seventy papers were presented.

The executive committee reported one hundred new members elected since September; the University of North Carolina at Chapel Hill as the next meeting place; appropriation of funds to provide additional lantern slides for high-school loans; the treasurer's report (including delinquencies) to be submitted to the auditing committee before July 1st and published in the *Proceedings*.

The academy adopted the recommendations of the high-school science committee for its continued activity with high-school teachers, including the organization

[1] *Am. Jour. Math.*, 60: 897, 1938.

of clubs and fairs, the continuation of the projects award, the extension of the lantern slide loan program and the continuation of the "discussion meeting" for high-school teachers at the time and place of the academy meeting. The academy appropriated additional funds for lantern slides.

The high-school projects award of $20.00 was voted to Mr. Don Fisher, of the Salisbury High School, and Mr. Clyde Vaugh, of the Charlotte High School, was recommended for the junior membership in the American Association for the Advancement of Science.

The research grants committee for the American Association research grant recommended that the grant be divided between S. B. Knight and H. W. Jensen.

Resolutions upon the death of Dr. A. A. Dixon, of State College, were adopted by a rising vote.

The report of the conservation committee dealt with the problems of making the great Dismal Swamp a national preserve, governmental purchase of certain wooded mountain areas and the commercialization of the venus fly trap and its possible extinction.

Action was taken supporting the report of the subcommittee of the academy conference on the "Relations of the American Institute to the Junior Academy."

The Poteat Award for the most noteworthy paper presented before the academy was given to Dr. N. F. Conant, of the Duke Medical School.

The report of the treasurer was ordered printed in the *Proceedings* after being properly audited.

The following officers were elected:

President: J. L. Stuckey, State College.

Vice-President: O. J. Thies, Davidson College.

New member of the Executive Committee: A. S. Pearse, Duke University.

New members of the Research Grants Committee: O. C. Bradbury, Wake Forest and H. D. Crockford, University of North Carolina.

The following were elected as officers of sections:

Botany: Chairman, J. N. Couch; *Secretary,* Earl H. Hall.

Geology: Chairman, J. W. Huddle; *Secretary,* Willard Berry.

Physics: Chairman, R. H. Lyddane; *Secretary,* F. W. Lancaster.

Psychology: Chairman, O. H. Lundholm; *Secretary,* J. F. Dashiell.

Zoology: Chairman, H. F. Prytherch; *Secretary,* Z. P. Metcalf.

High School Science Teachers: Chairman, Thomas Baldwin; *Secretary,* John W. Wood.

Davidson College entertained the academy in excellent style; administration, faculty and students cooperated to make the meeting pleasant and successful. The college entertained at dinner on Friday evening, and following the retiring presidental address by Dr. H. L. Blomquist on "Grasses and Man," provided a social hour where old acquaintances could be renewed and new ones made.

BERT CUNNINGHAM,
Secretary

DUKE UNIVERSITY

SPECIAL ARTICLES

BIOTIN (BIOS II_B, VITAMIN H)—AN ESSENTIAL GROWTH FACTOR FOR CERTAIN STAPHYLOCOCCI

THE basic nutritional requirements of *Staphylococcus aureus* have only recently been elucidated. In a medium composed of amino acids, glucose and inorganic salts, it has been necessary to add a minute amount of an unidentified supplement before aerobic growth will occur. Knight[1] first resolved the supplement into three parts, two being the pyrimidine and thiazole components of vitamin B_1, and the third being nicotinamide, a component of Warburg's coenzymes. For the anaerobic growth of this bacterium, Richardson[2] has demonstrated that uracil must be added to the medium, in addition to the above compounds.

A study was undertaken in our laboratory to determine whether the quantity of growth produced by several strains of *Staphylococcus aureus* in a chemically-defined medium (Gladstone[3]) was equal to that obtainable in standard glucose meat-infusion broth. The quantity of growth was determined by measuring the bacterial nitrogen with a micro-Kjeldahl technique. Preliminary results revealed that the chemically-defined medium was inferior to glucose meat-infusion broth. More interesting, however, was the fact that certain strains could not initiate growth in the synthetic medium on continued subculture. In an attempt to ascertain the substance or substances required for growth by these more fastidious strains, the chemically-defined medium of Gladstone was supplemented with several other compounds which have been demonstrated to be of importance in bacterial nutrition. These included other amino acids (norleucine, asparagine, α-amino valeric acid, β-amino valeric acid, taurine, threonine, β-alanine, diiodotyrosine and ornithine) in addition to the sixteen present in the basic medium, as well as the growth factors: riboflavin,[4] ino-

1 B. C. J. G. Knight, *Biochem. Jour.*, 31: 731, 966, 1937.
2 G. M. Richardson, *Biochem. Jour.*, 30: 2184, 1936.
3 G. P. Gladstone, *Brit. Jour. Exp. Path.*, 18: 322, 1937.
4 For these compounds we wish to thank the Research Department of Merck and Company, Dr. Henry Tauber and Professor Roger J. Williams.

sitol, pimelic acid, glutamine, glutathione, vitamin B_6,[4] pantothenic acid,[4] cocarboxylase,[4] cozymase,[4] uracil, guanine, adenine, adenylic acid[4] and adenosine triphosphate.[4] Repeated attempts to cultivate these staphylococci in media containing various concentrations of the above compounds met with failure. It thus became apparent that some other nutrient or vitamin-like substance was needed.

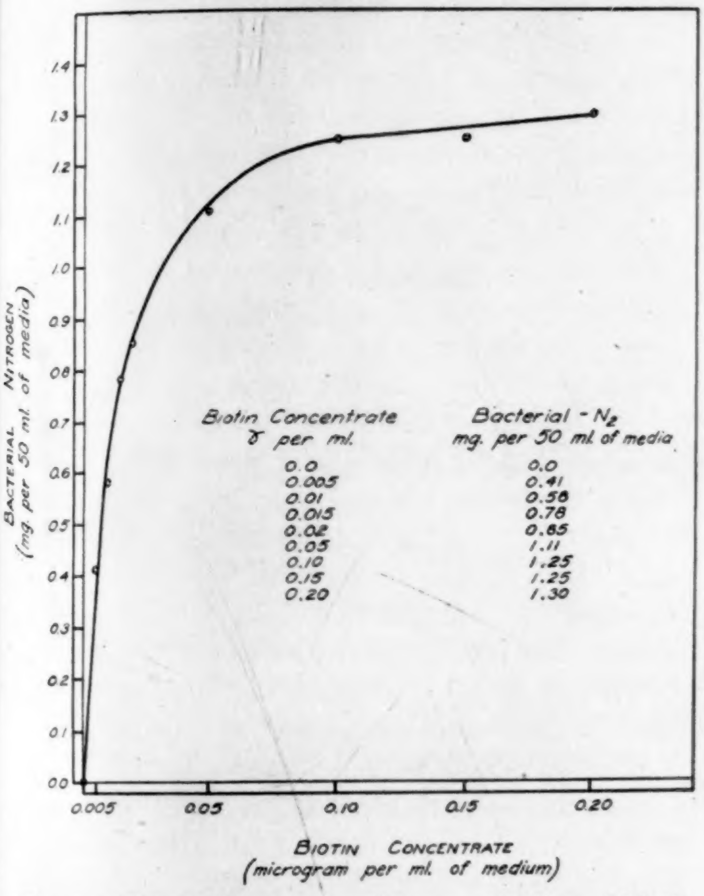


FIG. 1. **Effect of increasing the concentration of biotin** on the growth of ***Staphylococcus aureus*** **(X 3 strain).**

At this time extracts of both plant and animal tissues were prepared, subjected to various chemical treatments and tested for their growth-promoting properties. The results indicated that the additional growth factor required by these organisms could be readily adsorbed on charcoal and eluted with acetone containing ammonia. This suggested that we were probably dealing with biotin or some closely allied substance. Following the procedure of Kögl and Tönnis[5] for the purification of biotin, we prepared a concentrate from dried egg yolks[6] which permitted growth of these staphylococci in a concentration as low as 0.0001 microgram per milliliter, when added to Gladstone's medium. At the same time it was observed that a relationship existed between the amount of growth which took place and the concentration of biotin in the medium. This relationship was investigated quantitatively by cultivating the organisms in media containing various concentrations of the biotin preparation. After incubation at 37° C. for twenty-four hours, the amount of bacterial nitrogen was measured by a micro-Kjeldahl technique. Typical results are presented in Fig. 1, where it will be seen that the addition of a very minute amount of the biotin preparation gave a marked stimulation. A concentration of about one-tenth microgram per milliliter resulted in maximum growth under the conditions of this experiment. Without biotin, growth was neither detectable visibly nor by quantitative measurement. Similar stimulation was also observed by measurements using a photoelectric turbidimeter.

It is of interest that we have been able to replace our biotin concentrate with a preparation of bios II_B, furnished by Dr. C. N. Frey, of Fleischmann Laboratories, and a sample of vitamin H, from Dr. P. György. This fact lends further support to the recent work of György, Melville, Burk and du Vigneaud,[7] who have indicated that vitamin H, biotin and the co-enzyme R factor are porbably identical.

The manner in which these particular strains of *Staphylococcus aureus* respond to the biotin, bios II_B, or vitamin H concentrates, suggests the possibility of using them for the bio-assay of these substances. Employing such strains in a technique similar to the yeast-growth test of Snell, Eakin and Williams[8] might be advantageous, since biotin (bios II_B, vitamin H) is essential before any detectable growth will occur. Evaluation of such a technique must naturally await experimental data obtained with crystalline biotin.

J. R. PORTER
MICHAEL J. PELCZAR, JR.
STATE UNIVERSITY OF IOWA

CHANGES IN THE CONNECTIVE TISSUE OF THE UTERUS AND VAGINA OF THE RAT ASSOCIATED WITH ADVANCING AGE[1]

LOEB[2, 3] and associates found that with advancing age there is an increase in the amount of fibrillar and hyaline connective tissue in the uterus, vagina and cervix of the mouse. Using methods which differentiate reticulum from collagen, we have carried out similar studies in the rat. Seventy-six rats varying in age from 15 to 823 days of age were used. Tissues were

[5] F. Kögl and B. Tönnis, *Ztschr. physiol. Chem.*, 242: 43, 1936.

[6] For the dried egg yolks we wish to thank V. Conquest, director of research, Armour and Company.

[7] P. György, D. B. Melville, D. Burk, V. du Vigneaud, SCIENCE, 91: 243, 1940.

[8] E. E. Snell, R. E. Eakin and R. J. Williams, *Jour. Am. Chem. Soc.*, 62: 175, 1940.

[1] These studies were aided by grants from the Josiah Macy, Jr. Foundation and from the International Cancer Research Foundation.

[2] Leo Loeb, V. Suntzeff and E. L. Burns, SCIENCE, 88: 432–433, 1938.

[3] Leo Loeb, V. Suntzeff and E. L. Burns, *Am. Jour. Cancer*, 35: 159–174, 1939.

fixed in 10 per cent. formalin and stained by Gömöri's[4] method for the demonstration of reticulum and collagen. This procedure stains reticulum black and collagen old-rose.

These studies support the view that reticulum is a precollagenous type of connective tissue and may be transformed into collagen. A transitional phase was found between the two. The uterine connective tissue of the 15-day rat was chiefly reticulum. In the endometrium a fine reticular network extended from beneath the lining epithelium, where it was condensed to form a basement membrane, to or almost to the circular smooth muscle (C.S.M.). A narrow zone of collagen usually bordered the C.S.M. A network of reticulum was found about the muscle cells in both the circular and longitudinal smooth muscle (L.S.M.) layers. Peripheral to the L.S.M. and underlying the serosa a condensation of narrow collagen fibers formed a subserosal layer. Numerous trabeculae extended inward and divided the L.S.M. layer into irregular columns of cells. The connective tissue of the vaginal mucosa was definitely collagenous, although immediately below the epithelium a narrow line of argyrophilic material was found.

In increasing older rats there was in the uterus a gradual transformation of reticulum into collagen and a definite increase in the amounts of collagen which was most marked in the very old animals. Such changes occurred earliest and most markedly in the endometrium. In rats over six months of age collagen extended from the C.S.M. practically to the lining epithelium, although a reticular basement membrane almost invariably persisted even in the oldest rats. Here there was a gradual thickening of the collagen fiber bundles which often measured as much as 12 micra. As age increased there was a tendency for the reticulum of the C.S.M. and the L.S.M. to be transformed into collagen. These changes, however, were extensive only in rats over eighteen months of age. The subserosal layer and the trabeculae penetrating the L.S.M. became markedly thickened. Throughout life, and especially in the very old animals, there was an increase in the size and density of the collagenous fibers of the vaginal mucosa.

J. M. WOLFE
ETHEL BURACK
WINIFRED LANSING
A. W. WRIGHT

ALBANY MEDICAL COLLEGE,
UNION UNIVERSITY

RADIOACTIVE NITROGEN IN THE STUDY OF N_2 FIXATION BY NON-LEGUMINOUS PLANTS

THERE has been considerable controversy regarding the ability of non-leguminous plants to fix atmospheric nitrogen. Lipman and Taylor[1,2] and many others have presented positive evidence for N_2 fixation by wheat, barley, etc. In the experiments of Lipman and Taylor plants were grown both in the presence and absence of nitrogenous salts and were analyzed by a modified Kjeldahl method. The results showed that the plants contained more N than could have been obtained from the growth media. However, their conclusions have not been generally accepted.

It should be possible, using radioactive nitrogen, to obtain additional information regarding this problem. Despite the 10.5 minute half-life of N^{13} the yields obtainable in the Berkeley cyclotron are such as to make this feasible. The nuclear reactions are:

$$ {}_1D^2 + {}_6C^{12} \rightarrow {}_7N^{13} + {}_0n^1 \text{ and } {}_7N^{13} \rightarrow e^+ + {}_6C^{13}. $$

Carbon (charcoal) was bombarded in a gas-tight chamber incorporating many features found to be of value in the Radiation Laboratory for the handling of high intensity beams. The active gas in the target holder was passed through a heated combustion tube containing cupric oxide into a pyrex desiccator containing the barley plants. Only the tops were used; the plants were cut well above the roots to eliminate any bacteria clinging to the roots. The charcoal which contained the major fraction of the N^{13} was introduced into the combustion tube and burned in a stream of O_2. As a control an equal weight of barley killed by immersion in boiling water was present in the desiccator.

After the plants were exposed to the N_2^* for ~20 minutes they were removed and extracted with boiling 80 per cent. ethanol. After filtration the extract was boiled vigorously in a stream of air. The method of counting has been described elsewhere.[3] In the first experiments both the live and dead plants were found to contain N*. This was due to the presence of radioactive combined nitrogen (*i.e.,* CN, NH_3, NO, etc.) produced by the recoiling N^{13} atoms during the bombardment with the energetic (8 MEV) deuterons. The N_2^* was purified of combined nitrogen by slowly passing the active gases over heated CuO and then through a series of five traps and spirals immersed in liquid air. Before entering the trap system the gas stream was passed through solutions of HNO_3 and NH_4OH. The effectiveness of the purification was shown by the fact that no traces of NH_3 could be detected with Nessler's reagent, which is extremely sensitive for small amounts of NH_3.

Observing these precautions the live plants were found to contain N*, while no activity (< 1 per cent.) could be detected in the control plants. The results of a typical experiment are shown in Table 1. The activ-

[4] G. Gömöri, *Am. Jour. Path.*, 13: 993–1001, 1937.

[1] Lipman and Taylor, SCIENCE, 56: 605, 1922.
[2] Lipman and Taylor, *Jour. Frank. Inst.*, 198: 475, 1924.
[3] Ruben, Hassid and Kamen, *Jour. Am. Chem. Soc.*, 61: 661, 1939.

TABLE 1

	Exposure to N_2	Activity (counts/minute)[a]
[B]arley[b]	20 min.	200 ± 4
[F]reshly killed barley	" "	2 ± 2

[a] At the time of counting.
[b] 30 grams fresh weight.

[activit]y had the N^{13} half-life. The plants assimilated 10^{-4} [t]o 10^{-5} of the available N_2^*. For the experiment [sh]own in Table 1 this corresponds roughly to 0.01 cc [o]f N_2. Although the experimental conditions are [w]idely different and a quantitative comparison is dif[fi]cult, it is of interest to note that this figure is of the [s]ame order of magnitude as the rate of N_2 fixation cal[cu]lated from the data of Lipman and Taylor.[2]

These experiments with N^{13} do not necessarily prove [th]at a net uptake of N_2 has occurred, since the exis[te]nce of reversible (interchange) reactions involving [N]$_2$ is possible. This possibility, however, seems rather remote, and therefore it is not unreasonable to consider these experiments as positive evidence for N_2 fixation by non-leguminous plants.

Due to the magnitude of the assimilation it was not possible to determine into what compound the N_2 was converted. However, experiments are in progress to study the mechanism of N_2 fixation by the known N_2 fixing organisms (Azotobacter, legumes, etc.). It is unfortunate that a longer-lived radioactive nitrogen isotope is not available. It is apparent, however, that stable N^{15} can be used more effectively in a study of these problems.

We are indebted to Professor E. O. Lawrence and members of the Radiation Laboratory for their interest and cooperation.

S. RUBEN
W. Z. HASSID
M. D. KAMEN

UNIVERSITY OF CALIFORNIA,
BERKELEY

SCIENTIFIC APPARATUS AND LABORATORY METHODS

HEPARIN AS AN ANTICOAGULANT FOR PERMEABILITY STUDIES[1]

NUCLEATED erythrocytes, especially those of the [c]hicken, have been used in this laboratory for studies [o]f permeability and respiration. For measurements [o]f oxygen consumption the nucleated cells are much [m]ore satisfactory than the enucleated erythrocytes of [th]e mammals. This is due to the difference in rates of [o]xygen consumption between these two types of cells. [F]or permeability studies, however, the mammalian cells [a]re much easier to use. Nucleated erythrocytes in [sl]ightly acid media, for example, behave in an abnormal [f]ashion. In attempting to investigate the effect of pH [o]n osmotic hemolysis in chicken erythrocytes it was [n]ecessary to centrifuge the cells several times. When [a]ttempts were made to resuspend cells after this treat[m]ent it was often found that they had formed a sticky [m]ass which could not be broken up. Other experiments [i]n which partially hemolyzed cells were centrifuged [g]ave similar results. In all of these experiments the [bl]ood had either been defibrinated or oxalate had been [a]dded to prevent clotting.

In experiments in which heparin was used as an [a]nticoagulant (Glogau—1 mg per 10 cc of blood) it [w]as found that the cells could be treated in the manner [d]escribed above, with much less tendency for them to [st]ick together in a stringy mass. It would seem, then, [th]at heparinized chicken blood left the cells in a con[d]ition much more suitable for experimentation.

Circumstantial evidence would suggest that this difference in behavior might be due to differences in the Ca^{++}. In both defibrinated blood and oxalated blood the Ca^{++} is below the normal level. In heparinized blood, however, the Ca^{++} should be at the normal level. Although the direct effect of Ca^{++} and its interaction with other ions such as Na^+ and K^+ are controversial subjects (for a general discussion of this problem see Heilbrunn[2]), there are a large number of data which indicate that protoplasmic properties such as viscosity, etc., are dependent on Ca^{++}. A detailed investigation would be necessary before one could be certain that a lowered Ca^{++} caused the sticking together of these cells.

The authors recommend, then, the use of heparin as an anticoagulant in investigations in which nucleated erythrocytes are subjected to much experimentation. The cells appear to be more nearly normal, and have less tendency to stick together in an unusable mass.

F. R. HUNTER
L. D. STRINGER
H. D. WEISS

RHODE ISLAND STATE COLLEGE

[1] One of the authors, F. R. Hunter, is indebted to the [A]merican Association for the Advancement of Science [a]nd to the American Academy of Arts and Sciences for [gr]ants-in-aid.

[2] L. V. Heilbrunn, "An Outline of General Physiology," W. B. Saunders Co., Philadelphia, 1937.

A NEW TECHNIC FOR STAINING VAGINAL SMEARS: II[1]

IN a recent communication to this journal[2] a new technic was described for staining vaginal smears, employing a modified Masson trichrome stain. This stain added a series of color changes to the cytological altera-

[1] Aided by a grant from the Josiah Macy, Jr., Foundation.

[2] SCIENCE, 91: 321, 1940.

tions in the smears, greatly facilitating their interpretation. Attempts to simplify the technic as well as to avoid the necessity for relying on imported stains such as Ponceau de Xylidene and Light Green have since been carried out. These have been greatly facilitated by the report of Lillie[3] that domestic Biebrich Scarlet and Fast Green FCF may be substituted for Ponceau de Xylidene and Light Green respectively; and that a mixture of equal parts of 5 per cent. phosphomolybdic and phosphotungstic acids gives adequate mordanting in one minute. On this basis, it has been possible to simplify and shorten the technic previously described for the vaginal smear and use domestic stains exclusively.

The revised staining technic embracing these modifications is as follows:

(1) From fixing solution, carry through alcohols to water; stain with Harris Hematoxylon for 2 minutes, and wash in running water for 5 minutes.

(2) Instead of the Ponceau de Xylidene-Acid Fuchsin-Orange G solution, 1 per cent. Biebrich Scarlet, water soluble (Nat'l Aniline and Chem. Co.) and 0.4 per cent. Orange G in 1 per cent. acetic acid. Stain 1 minute and rinse in water.

(3) In place of the 3 per cent. phosphotungstic acid mordant, a mixture of equal parts of 5 per cent. phosphomolybdic and phosphotungstic acids. Mordant 1 minute and rinse.

(4) In place of 0.3 per cent. Light Green, a 0.25 per cent. solution of Fast Green FCF (Nat'l Aniline and Chem. Co.) in 0.3 per cent. acetic acid. Stain 2 minutes. Do not rinse.

(5) Differentiate in 1 per cent. acetic acid for 1 minute, carry through alcohols to xylol and mount in damar.

It is possible to omit the hematoxylin stain under certain conditions, as in the routine treatment of the menopause with estrogens. With this omission, the smear can be stained in 5 minutes.

The assistance of Eugene J. Cohen in working out these modifications is gratefully acknowledged.

EPHRAIM SHORR

THE NEW YORK HOSPITAL AND THE DEPARTMENT OF MEDICINE, CORNELL UNIVERSITY MEDICAL COLLEGE, NEW YORK, N. Y.

[3] *Stain Technology*, 15: 17, 1940.

SOLUTIONS OF CHLOROPHYLL IN SALT WATER

ALTHOUGH a number of workers have studied aqueous extracts of chlorophyll from fresh leaves, only Inman[1] seems to have discovered that the addition of salt to the water is beneficial. Since Inman seems never to have published his findings in this respect, and since the author hasn't time to do adequate research with the method, it seems worth publishing this statement.

As various workers have stated, chlorophyll can be suspended in water if fresh leaves are ground in water, either with or without an abrasive. However, the suspended chlorophyll settles out within a few hours (with a few exceptions). Smith[2] has found that the addition to the colloid solution of a detergent will keep the chlorophyll in suspension. Less drastic treatment than that will stabilize the colloid. It is only necessary to grind the leaves with a salt and water solution rather than pure water.

Na_2SO_4 and NaCl have been found effective. The optimum concentration for NaCl is between 2 per cent. and 5 per cent. Since it has seemed desirable to control the pH, M/15 phosphate buffer of pH 7 is being used at present, and it gives very satisfactory solutions. $CaCl_2$ will not maintain the colloid in suspension. Buffers of pH 6 and below are not satisfactory, for the chlorophyll tends to decompose. Borate buffers at pH's 8 and 11 seem satisfactory, but it is feared that the high pH may change the chlorophyll in some way.

The chlorophyll suspension obtained in salt solution is never clear. It possesses the various properties reported heretofore. It is relatively photostable, is precipitated by protein coagulants, passes through filter paper, is difficult to centrifuge down, has the red absorption band in the same place as that of an intact leaf, behaves as if negatively charged in cataphoresis, can be precipitated by ammonium sulfate and redissolved by addition of fresh buffer solution.

JOHN SHAFER, JR.

CORNELL UNIVERSITY

[1] O. L. Inman and M. L. Crowell, *Plant Physiol.*, 14: 388–390, 1939; also in private conversation.

[2] E. L. Smith, SCIENCE, 91: 199–200, 1940.

BOOKS RECEIVED

BRUMBAUGH, A. J., Editor. *Boucher's Chicago College Plan.* Revised edition. Pp. x + 413. University of Chicago Press. $3.00.

CAMPBELL, DOUGLAS H. *The Evolution of the Land Plants (Embryophyta).* Pp. ix + 731. 351 figures. Stanford University Press. $6.50.

GOLDSCHMIDT, RICHARD. *The Material Basis of Evolution.* Pp. xi + 436. 83 figures. Yale University Press. $5.00.

Highway Research Board. *Proceedings of the Nineteenth Annual Meeting, 1939.* Pp. 573. Illustrated. National Research Council, Washington.

HILGARD, ERNEST R. and DONALD G. MARQUIS. *Conditioning and Learning.* Pp. xi + 429. Appleton-Century. $2.75.

SAND, H. J. S. *Electrochemistry and Electrochemical Analysis: Vol. II, Gravimetric Electrolytic Analysis and Electrolytic Marsh Tests.* Pp. ix + 149. Illustrated. Blackie and Son, Glasgow. 5/–.

Smithsonian Institution. *Miscellaneous Collections: Vol. 100, Essays in Historical Anthropology of North America.* Pp. 600. 34 figures. 16 plates. The Institution.

Woods Hole Oceanographic Institution. *Collected Reprints, 1939.* The Institution.